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Thomas E. Keane
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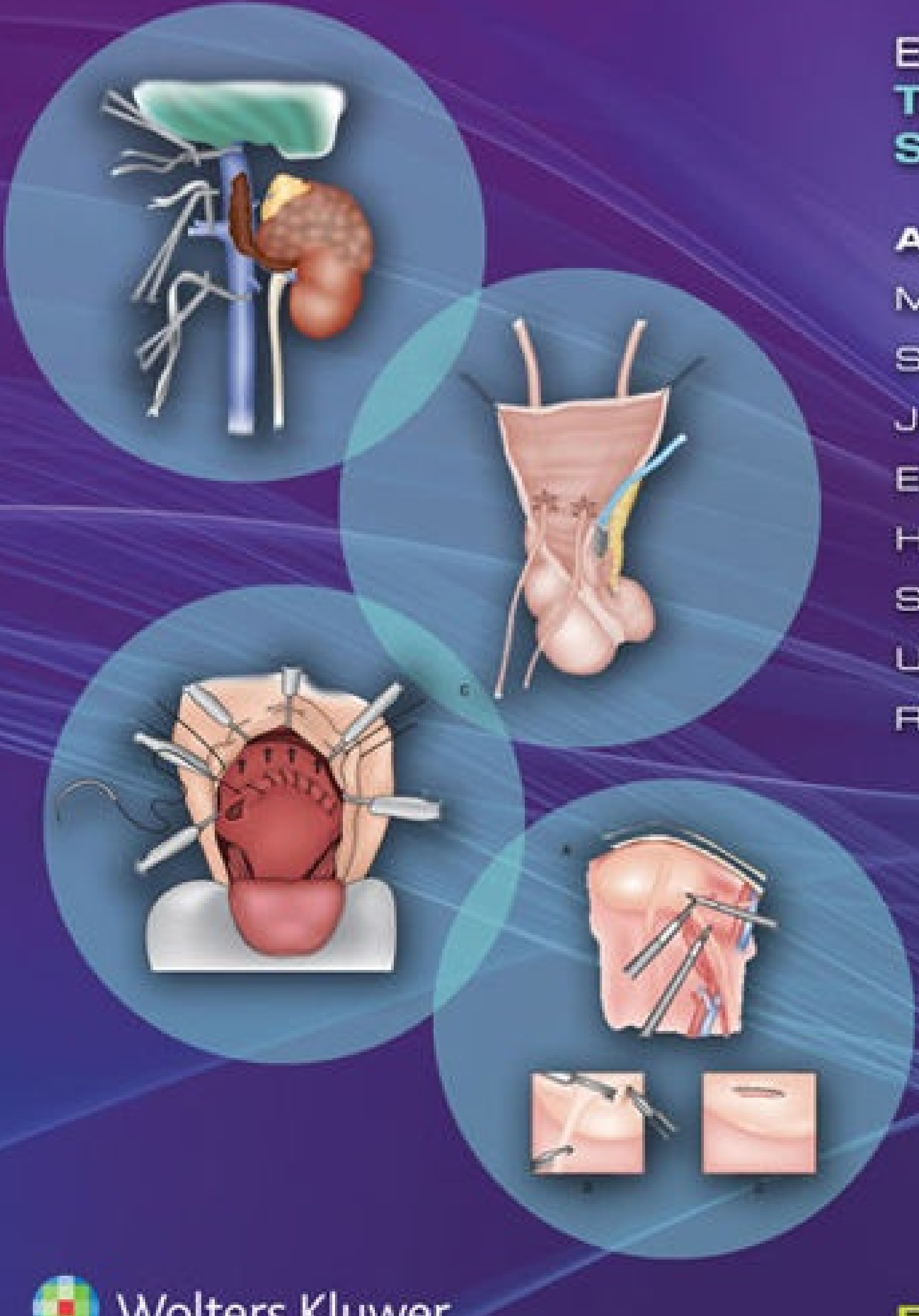

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Editors

Thomas E. Keane, MD
Professor and Chair
Department of Urology
Medical University of South Carolina
Charleston, South Carolina

Sam D. Graham, Jr., MD
Urologic Specialists of Virginia
Blue Ridge Urology
Fishersville, Virginia

Associate Editors
Marc Goldstein, MD, DSc (hon), FACS
Sandip M. Prasad, MD, MPhil
Jerome P. Richie, MD
Eric S. Rovner, MD
H. Gil Rushton, MD
Stephen J. Savage, MD
Urs E. Studer, MD
Ramón Virasoro, MD

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EDITORS

Thomas E. Keane, MD
Professor and Chair
Department of Urology
Medical University of South Carolina
Charleston, South Carolina

Sam D. Graham, Jr., MD
Urologic Specialists of Virginia
Blue Ridge Urology
Fishersville, Virginia

Associate Editors

Marc Goldstein, MD, DSc (hon), FACS
Matthew P. Hardy Distinguished Professor of Reproductive Medicine and Urology
Cornell Institute for Reproductive Medicine
Medical College of Cornell University
Senior Scientist
Center for Biomedical Research
Population Council
Surgeon-in-Chief, Male Reproductive Medicine and Surgery
Cornell Institute for Male Reproductive Medicine and Department of Urology
New York-Presbyterian Hospital/Weill Cornell Medical Center
New York, New York

Sandip M. Prasad, MD, MPhil
Assistant Professor
Department of Urology
Medical University of South Carolina
Charleston, South Carolina

Jerome P. Richie, MD
Elliott C. Cutler Professor of Urological Surgery
Harvard Medical School
Chief of Urology (Emeritus)
Department of Surgery
Brigham and Women’s Hospital
Boston, Massachusetts

Eric S. Rovner, MD
Professor of Urology
Attending Staff
Department of Urology

Medical University of South Carolina
Charleston, South Carolina

H. Gil Rushton, MD

Chief, Division of Pediatric Urology
Children's National Medical Center
Professor of Urology and Pediatrics
The George Washington University School of Medicine
Washington, DC

Stephen J. Savage, MD

Professor and Vice Chairman
Department of Urology
Medical University of South Carolina
Chief
Section of Urology
Ralph H. Johnson VA Medical Center
Charleston, South Carolina

Urs E. Studer, MD

Professor
Expert Consultant
Department of Urology
University Hospital Bern
Bern, Switzerland

Ramón Virasoro, MD

Assistant Professor
Department of Urology
Eastern Virginia Medical School
Virginia Beach, Virginia

CONTRIBUTORS

Hassan Abol-Enein, MD, PhD
Professor
Department of Urology
Faculty of Medicine, Mansoura University
Director
Department of Urology
Urology and Nephrology Center
Mansoura, Egypt

Andre Luis de Castro Abreu, MD
Fellow of Advanced Robotic and Laparoscopic Urologic Surgery
USC Institute of Urology
University of Southern California
Clinical Fellow of Minimally Invasive Urologic Surgery
USC Institute of Urology
Keck Hospital of University of Southern California
Los Angeles, California

Khalid Alrabeeah, MBBS, FRCS(C)
Division of Urology
Department of Surgery
King Saud bin Abdulaziz University for Health Sciences
King Abdulaziz Medical City
Riyadh, Saudi Arabia

Kenneth W. Angermeier, MD
Director
Center for Genitourinary Reconstruction
Glickman Urological and Kidney Institute
Cleveland Clinic
Cleveland, Ohio

Magnus Annerstedt
Department of Molecular Medicine and Surgery
Karolinska Institute
Karolinska University
Hospital Chief Department of Urology STHLM Läkarhuset
Odenplan Stockholm, Sweden

Angela M. Arlen, MD
Fellow in Pediatric Urology
Department of Urology
Emory University and Children’s Healthcare of Atlanta

Atlanta, Georgia

J. Christopher Austin, MD
Associate Professor
Department of Urology
Oregon Health & Sciences University
Pediatric Urologist
Department of Urology
Doernbecher Children’s Hospital
Portland, Oregon

Hajar I. Ayoub, MD
Urinary Tract and Pelvic Reconstruction Fellow
MD Anderson Cancer Center
Houston, Texas

Christian Andreas Bach, MD, FRCS(Urol), FEBU
Consultant Urological Surgeon
Department of Urology
Freeman Hospital
Newcastle upon Tyne, United Kingdom

John M. Barry, MD
Professor
Departments of Urology and Surgery
Oregon Health & Science University
Director, Living Donor Kidney Transplantation
Department of Surgery
Oregon Health & Science University Hospital
Portland, Oregon

Laurence S. Baskin, MD, FAAP, FACS
Frank Hinman, Jr., MD, Distinguished Professorship in Pediatric Urology
Chief Pediatric Urology
Professor Urology and Pediatrics
UCSF Children’s Hospital
University of California, San Francisco
San Francisco, California

Jean-Christophe Bernhard, MD, PhD
Associate Professor
Department of Urology and Renal Transplantation
University of Bordeaux
Bordeaux, France
Catherine and Joseph Aresty Department of Urology
USC Institute of Urology—Norris Comprehensive Cancer Center
Los Angeles, California

Diana K. Bowen, MD
Resident Physician
Department of Urology
Northwestern University
Northwestern Memorial Hospital
Chicago, Illinois

Steven B. Brandes, MD, FACS
Professor of Urologic Surgery
Division of Urology
Washington University in St. Louis
Urology Residency Director
Division of Urology
Barnes-Jewish Hospital
St. Louis, Missouri

Robert E. Brannigan, MD
Associate Professor
Director of Andrology Fellowship
Department of Urology
Northwestern University Feinberg School of Medicine
Attending Physician
Department of Urology
Northwestern Memorial Hospital
Chicago, Illinois

Jill C. Buckley, MD, FACS
Associate Professor
Department of Urology
Genitourinary Reconstructive Urology
UC San Diego Health Systems
San Diego, California

Fiona Burkhard, MD
Associate Professor
University of Bern
Vice Chairwoman
Department of Urology
University Hospital of Bern
Bern, Switzerland

Arthur L. Burnett II, MD, MBA, FACS
Patrick C. Walsh Distinguished Professor of Urology
Department of Urology
Johns Hopkins Medical Institutions
Baltimore, Maryland

Amy S. Burns, MD
Assistant Professor of Surgery
Division of Pediatric Urology
Penn State Hershey Medical Center
Hershey, Pennsylvania

Jeffrey A. Cadeddu, MD
Department of Urology
UT Southwestern Medical Center
UT Southwestern Department of Urology
Dallas, Texas

Mark P. Cain, MD, FAAP
Professor
Department of Urology
Indiana University
Chief of Pediatric Urology
Division of Urology
Riley Hospital for Children at IU Health
Indianapolis, Indiana

Anthony A. Caldamone, MD, MMS, FACS, FAAP
Professor of Surgery (Urology) and Pediatrics
Division of Urology
Alpert Medical School of Brown University
Director of Pediatric Urology
Division of Urology
Hasbro Children's Hospital
Providence, Rhode Island

Douglas A. Canning, MD
Professor
Department of Surgery (Urology)
University of Pennsylvania
Chief
Division of Urology
The Children's Hospital of Philadelphia
Philadelphia, Pennsylvania

Glenn M. Cannon, Jr., MD
Associate Professor
Department of Urology
University of Pittsburgh School of Medicine
Children's Hospital of Pittsburgh of UPMC
Pittsburgh, Pennsylvania

K. Jeff Carney, MD, PharmD

Assistant Professor of Urology
Department of Urology
Emory University
Chief of Urology
Grady Memorial Hospital
Atlanta, Georgia

Culley C. Carson, MD, FACS
Rhodes Distinguished Professor of Urology Department of Urology
Division of Urology
University of North Carolina
Chapel Hill, North Carolina

Anthony J. Casale, MD
Professor
Department of Urology and Pediatrics
Albert Einstein College of Medicine
New York, New York
Chief, Division of Pediatric Urology
Department of Urology
Children’s Hospital at Montefiore
Bronx, New York

Pasquale Casale, MD
John and Irene Given Professor of Urology
Department of Urology
Columbia University Medical Center
Chief of Pediatric Urology
Division of Pediatric Urology
Morgan Stanley Children’s Hospital/New York-Presbyterian
New York, New York

Peter Chan, MD, CM, MSc, FRCS(C), FACS
Director of Male Reproductive Medicine
Division of Urology, Department of Surgery
McGill University
McGill University Health Centre
Montreal, Quebec, Canada

Sam S. Chang, MD, MBA
Professor of Urologic Surgery
Patricia and Rodes Hart Chair of Urologic Surgery
Department of Urologic Surgery
Vanderbilt University Medical Center
Nashville, Tennessee

Kelly A. Chiles, MD, MSc

Fellow
Department of Urology
Weill Cornell Medical College
New York, New York

Sameer Chopra, MD
Urologic Oncology Research Fellow
USC Institute of Urology
University of Southern California
Urologic Oncology Research Fellow
USC Institute of Urology
Keck Hospital of the University of Southern California
Los Angeles, California

Harry S. Clarke, MD, PhD
Professor of Urology
Department of Urology
Medical University of South Carolina
Charleston, South Carolina

Clinton W. Collins, MD
Chief Resident
Division of Urology
Virginia Commonwealth University School of Medicine
Richmond, Virginia

Craig V. Comiter, MD
Professor
Department of Urology
Stanford University
Chief, Division of Urologic Specialties
Stanford Hospital & Clinics
Stanford, California

Michael S. Cookson, MD, MMHC
Professor and Chairman
Department of Urology
The University of Oklahoma
Norman, Oklahoma
Chief
Urology Department
Oklahoma University Medical Center
Oklahoma City, Oklahoma

Christopher S. Cooper, MD, FAAP
Professor
Department of Urology

The University of Iowa
Iowa City, Iowa

Robert M. Coward, MD
Assistant Professor
Department of Urology
University of North Carolina
Chapel Hill, North Carolina

Ali A. Dabaja, MD
Adjunct Clinical Assistant Professor
Department of Urology and Department of Male Reproductive Medicine
Weill Cornell Medical College
New York, New York
Director of Male Reproductive Medicine
Department of Urology
Henry Ford Health System
Detroit, Michigan

Lawrence M. Dagrosa, MD
Resident
Department of Surgery, Section of Urology
Dartmouth-Hitchcock Medical Center
Lebanon, New Hampshire

Teresa L. Danforth, MD
School of Medicine and Biomedical Sciences
Department of Urology
University at Buffalo
Buffalo, New York

G. Joel DeCastro, MD, MPH
Assistant Professor
Department of Urology
Columbia University Medical Center
Attending
Department of Urology
New York-Presbyterian Hospital—Columbia University
New York, New York

Ross M. Decter, MD
Thomas J. Rohner, Jr., MD, and Jesse F. Rohner, DrPH, Professor of Surgery
Department of Surgery, Division of Urology
Chief, Division of Urology
Penn State Milton S. Hershey Medical Center
Hershey, Pennsylvania

Stephan Degener, MD
Resident
Department of Urology and Pediatric Urology
University of Witten/Herdecke
Witten, Germany

David A. Diamond, MD
Professor of Urologic Surgery
Department of Urology
Harvard Medical School
Urologist-in-Chief
Department of Urology
Boston Children’s Hospital
Boston, Massachusetts

Roger R. Dmochowski, MD, MMHC, FACS
Professor of Urology and Gynecology
Department of Urology
Vanderbilt University Medical Center
Nashville, Tennessee

Lindsay Dow, BA
Department of Urology
Weill Cornell Medical College
New York, New York

Brooke Edwards, MD
Resident
Division of Urology
Eastern Virginia Medical School
Norfolk, Virginia

Michael J. Ehlert, MD
Fellow, Female Pelvic Medicine and Reconstructive Surgery
Department of Urology
Beaumont Health System
Royal Oak, Michigan

Ahmed M. El-Zawahry, MD, MSc
Assistant Professor
Surgery Department, Division of Urology
Southern Illinois University
Springfield, Illinois

Jairam R. Eswara, MD
Instructor
Division of Urology

Harvard Medical School
Associate Surgeon
Division of Urology
Brigham and Women’s Hospital
Boston, Massachusetts

Izak Faiena, MD
Resident
Division of Urology
Rutgers Robert Wood Johnson Medical School
New Brunswick, New Jersey

Walid A. Farhat, MD, FRCSC
Associate Professor
Department of Surgery
University of Toronto
The Hospital for Sick Children
Toronto, Ontario, Canada

Sarah Fraumann Faris, MD
Clinical Instructor
Reconstructive Urology Fellow
Department of Urology
The University of Iowa
Iowa City, Iowa

William C. Faust, MD
Clinical Associate
Department of Urology
Tufts University School of Medicine
Boston, Massachusetts
Chief Resident
Institute of Urology
Lahey Hospital and Medical Center
Burlington, Massachusetts

Kevin M. Feber, MD
Associate Professor
Department of Urology
Oakland University William Beaumont School of Medicine
Rochester, Michigan
Attending Physician
Department of Urology
Beaumont Health System
Royal Oak, Michigan

Margit Fisch, MD, FEBV, FEAEV

Professor of Urology and Chairwoman
Department of Urology
University Medical Center Hamburg-Eppendorf
Department of Urology
Hamburg, Germany

Ludger Franzaring, MD
Head of Department
Department of Urology
Gemeinschaftsklinikum Mittelrhein
Koblenz, Germany

John P. Gearhart, MD, FAAP, FACS, FRCS (Hon) (Ed)
Professor and Chief
Pediatric Urology
Johns Hopkins School of Medicine
Charlotte Bloomberg Children's Hospital
Baltimore, Maryland

Arvin K. George, MD
Minimally Invasive Surgery/Endourology Fellow
The Smith Institute for Urology
Hofstra North Shore-LIJ School of Medicine
New Hyde Park, New York

Elmar W. Gerharz, MD
Associate Professor of Urology
Department of Urology and Pediatric Urology
Julius Maximilians University Medical School
Würzburg, Germany
Staff Urologist
Urologie an der Paulskirche
UROGATE/Frankfurt Urology Associates
Frankfurt, Germany

Mohamed A. Ghoneim, MD, MD (Hon.), FACS (Hon.)
Professor of Urology
Urology and Nephrology Center
Mansoura University
Mansoura, Egypt

Gianluca Giannarini, MD
Clinical Research Fellow
Department of Urology
Inselspital
Bern, Switzerland

Inderbir S. Gill, MD, MCh
Chairman
USC Institute of Urology
University of Southern California
Keck Hospital of the University of Southern California
Los Angeles, California

David Gillatt, MB, FRCS, FRCS(E), FRCS (UROL), ChM
Professor
Department of Urology
Macquarie University
Director
Medical Services
Macquarie University Hospital
Sydney, Australia

David A. Ginsberg, MD
Associate Professor
Institute of Urology
Keck School of Medicine of the University of Southern California
Chief
Divisions of Urology
Rancho Los Amigos National Rehabilitation Center
Downey, California

Kenneth I. Glassberg, MD
Given Foundation Professor Emeritus
Department of Urology
Columbia University Medical Center
New York-Presbyterian Hospital
New York, New York

David A. Goldfarb, MD
Professor of Surgery
Glickman Urological and Kidney Institute
Cleveland Clinic
Cleveland, Ohio

Marc Goldstein, MD, DSc(hon), FACS
Matthew P. Hardy Distinguished Professor of Reproductive Medicine and Urology
Cornell Institute for Reproductive Medicine
Medical College of Cornell University
Senior Scientist
Center for Biomedical Research
Population Council
Surgeon-in-Chief, Male Reproductive Medicine and Surgery
Cornell Institute for Male Reproductive Medicine and Department of Urology

New York-Presbyterian Hospital/Weill Cornell Medical Center
New York, New York

Alex Gomelsky, MD
Professor of Clinical Urology
Department of Urology
Louisiana State University Health–Shreveport
Director of Female Urology, Neurourology, and Pelvic Reconstructive Surgery
Department of Urology
University Health Shreveport
Shreveport, Louisiana

Ana Maria Autrán Gómez, MD, PhD
Urology Fellow
Department of Urology
Hospital Universitario Cemic
Buenos Aires, Argentina

E. Ann Gormley, MD, FRCS, FACS
Professor of Surgery (Urology)
Department of Surgery
Geisel School of Medicine at Dartmouth
Hanover, New Hampshire
Urologist
Section of Urology
Dartmouth-Hitchcock Medical Center
Lebanon, New Hampshire

Angelo E. Gousse, MD
Clinical Professor of Surgery (Urology)
Herbert Wertheim College of Medicine—Florida International University
Miami, Florida
Director of Fellowship, Female Urology, Voiding Dysfunction, Reconstruction
Memorial Hospital Miramar, South Broward Hospital District
Miramar, Florida

Richard W. Grady, MD
Professor
Department of Urology
University of Washington
Attending Physician
Pediatric Urology
Seattle Children’s Hospital
Seattle, Washington

Sam D. Graham, Jr., MD
Urologic Specialists of Virginia

Blue Ridge Urology
Fishersville, Virginia

Chad M. Gridley, MD
Resident
Department of Urology
The Ohio State University
Wexner Medical Center
Columbus, Ohio

H. Albin Gritsch, MD
Associate Professor
Department of Urology
University of California
Surgical Director
Kidney Transplant Program
Ronald Reagan Medical Center
Los Angeles, California

Erik Grossgold, MD
Resident
Department of Urology
Eastern Virginia Medical School
Norfolk, Virginia

Thomas J. Guzzo, MD, MPH
Assistant Professor of Urology
Division of Urology
University of Pennsylvania
Philadelphia, Pennsylvania

Miriam Hadj-Moussa, MD
House Officer
Department of Urology
University of Michigan
Ann Arbor, Michigan

Judith C. Hagedorn, MD, MHS
Resident
Department of Urology
Stanford University
Stanford Hospital & Clinics
Stanford, California

Andrew D. Hardie, MD
Associate Professor of Radiology and Urology
Radiology and Radiological Sciences

Medical University of South Carolina
Charleston, South Carolina

Brooke A. Harnisch, MD
Fellow
Department of Urology
Medical College of Wisconsin
Department of Urology
Froedtert Hospital
Milwaukee, Wisconsin

Ahmed M. Harraz, MD, MS, MRCS
Lecturer
Department of Urology
Urology and Nephrology Center
Mansoura University
Mansoura, Egypt

Hashim Hashim, MBBS, MRCS (Eng), MD, FEBU, FRCS (Urol)
Honorary Senior Lecturer
University of Bristol
Consultant Urological Surgeon and Director of the Urodynamic Unit
Bristol Urological Institute
Southmead Hospital
Bristol, United Kingdom

Richard E. Hautmann, MD, MD (Hon)
Professor of Urology
Department of Urology
University of Ulm
Chairman Emeritus
Department of Urology
University of Ulm
Ulm, Germany

Samuel C. Haywood, MD
Resident
Glickman Urologic and Kidney Institute
Cleveland Clinic Foundation
Cleveland, Ohio

Sean P. Hedican, MD
Associate Professor
Department of Urology
University of Wisconsin School of Medicine and Public Health
Madison, Wisconsin

Axel Heidenreich, Prof. Dr. Med., MD, PhD
Director and Chairman
Department of Urology
Uniklinik RWTH Aachen
Aachen, Germany

Jim C. Hu, MD, MPH
Ronald Lynch Professor of Urologic Oncology
Director of the LeFrak Center for Robotic Surgery
James Buchanan Brady Foundation Department of Urology
Weill Cornell Medical College
New York-Presbyterian Hospital
New York, New York

Brian M. Inoyuye
Research Fellow
Department of Pediatric Urology
The Brady Urological Institute at the Johns Hopkins Hospital
Baltimore, Maryland

Gerald H. Jordan, MD, FACS, FAAP
Professor of Urology
Eastern Virginia Medical School
Director of Adult Reconstructive Surgery
The Devine Center for Genitourinary Reconstruction
Sentara Norfolk General Hospital
Devine-Fiveash Urology, Ltd.
Norfolk, Virginia

David B. Joseph, MD, FACS, FAAP
Professor
Department of Urology
University of Alabama at Birmingham
Chief of Pediatric Urology
Beverly P. Head Chair in Urology
Department of Urology
Children’s of Alabama
Birmingham, Alabama

Ying H. Jura, MD
Female Pelvic Medicine and Reconstructive Surgery
Fellow Department of Urology Stanford University
School of Medicine
Clinical Fellow Department of Urology
Stanford Hospital and Clinics
Stanford, California

Martin Kaefer, MD, FAAP
Professor, Pediatric Urology
Riley Hospital for Children
Indiana University School of Medicine
Indianapolis, Indiana

George W. Kaplan, MD, MS
Professor of Clinical Surgery and Pediatrics
Surgery Department
University of California San Diego
Senior Staff
Urology Department
Rady Children's Hospital San Diego
San Diego, California

Evan J. Kass, MD
Professor and Chief
Oakland University William Beaumont School of Medicine
Rochester, Michigan
Chief
Department of Pediatric Urology
Beaumont Children's Hospital
Beaumont Health System
Royal Oak, Michigan

Melissa R. Kaufman, MD, PhD
Associate Professor
Department of Urologic Surgery
Vanderbilt University
Nashville, Tennessee

Louis R. Kavoussi, MD, MBA
Waldbaum Gardiner Distinguished Professor
The Smith Institute for Urology
Hofstra North Shore-LIJ School of Medicine
Chairman of Urology
The Smith Institute for Urology
North Shore LIJ Health System
Lake Success, New York

Thomas E. Keane, MD
Professor and Chair
Department of Urology
Medical University of South Carolina
Charleston, South Carolina

Ja-Hong Kim, MD

Assistant Professor
Department of Urology
UCLA School of Medicine
Los Angeles, California

Simon Kimm, MD
Fellow in Urologic Oncology
Department of Surgery, Division of Urology
Memorial Sloan Kettering Cancer Center
New York, New York

Andrew J. Kirsch, MD, FAAP, FACS
Clinical Professor and Chief of Pediatric Urology
Department of Urology
Emory University
Children's Healthcare of Atlanta
Atlanta, Georgia

Adam P. Klausner, MD
Associate Professor and Warren W. Koontz Professor of Urologic Research
Division of Urology/Department of Surgery
Virginia Commonwealth University School of Medicine
Director of Neurology and Voiding Dysfunction
Division of Urology/Department of Surgery
Virginia Commonwealth University Medical Center
The H.H. McGuire Veterans Affairs Medical Center
Richmond, Virginia

Eric A. Klein, MD
Professor of Surgery
Chairman, Glickman Urologic and Kidney Institute
Cleveland Clinic Lerner College of Medicine
Cleveland Clinic
Cleveland, Ohio

Arkadius Kocot, MD
Department of Urology and Pediatric Urology
Julius Maximilians University of Würzburg
Würzburg, Germany

Chester J. Koh, MD
Associate Professor
Department of Pediatric Urology
Baylor College of Medicine
Attending Pediatric Urologist
Surgery Department
Texas Children's Hospital

Houston, Texas

Martin A. Koyle, MD, FAAP, FACS, FRCS (Eng), FRCSC
Professor of Surgery
University of Toronto
Division Head & Program Director
Pediatric Urology
Women's Auxiliary Chair in Urology & Regenerative Medicine
Hospital for Sick Children
Toronto, Ontario, Canada

Venkatesh Krishnamurthi, MD
Director, Kidney/Pancreas Transplant Program
Glickman Urological and Kidney Institute
Cleveland Clinic
Cleveland, Ohio

Jack W. Lambert, MD
Instructor
Department of Urology
Eastern Virginia Medical School
Sentara Norfolk General Hospital
Norfolk, Virginia

Benjamin R. Lee, MD, FACS
Professor of Urology & Oncology
Department of Urology
Tulane University School of Medicine
Fellowship Director
Department of Urology
Tulane Medical Center
New Orleans, Louisiana

Cheryl T. Lee
Associate Professor
Department of Urology
University of Michigan
Ann Arbor, Michigan

Daniel J. Lee, MD
Resident
Department of Urology
Weill Cornell Medical College
New York Presbyterian Hospital
New York, New York

Nora G. Lee, MD

Division of Urology
George Washington University
Children's National Medical Center
Washington, DC

Richard S. Lee, MD
Assistant Professor of Surgery (Urology)
Department of Urology
Harvard Medical School
Associate
Department of Urology
Boston Children's Hospital
Boston, Massachusetts

Jeffrey A. Leslie, MD, FAAP
Clinical Assistant Professor
Department of Urology
University of Texas Health Science Center at San Antonio
San Antonio, Texas

Ryan S. Levey, MD
Resident Physician
Department of Urology
Medical University of South Carolina
Charleston, South Carolina

John A. Libertino, MD
Professor
Department of Urology
Tufts University School of Medicine
Boston, Massachusetts
Chair, Institute of Urology
Lahey Clinic Medical Center
Burlington, Massachusetts

Robert John Lischer, BFA, MBA
Freelance Designer
Department of Urology
Weill Cornell Medical College
New York, New York

Christopher J. Long, MD
Pediatric Urology Fellow
Department of Surgery, Division of Urology
Children's Hospital of Philadelphia
Philadelphia, Pennsylvania

Joanne Lundgren, MD
Resident
Department of Urology
University of Michigan
Chief
Department of Urology
University of Michigan Health System
Ann Arbor, Michigan

Michael Maddox, MD
Clinical Instructor
Department of Urology
Tulane University School of Medicine
New Orleans, Louisiana

John H. Makari, MD, MHA, MA
Associate Professor of Surgery (Urology)
Division of Urology
University of Connecticut School of Medicine
Farmington, Connecticut
Attending Pediatric Urologist
Division of Urology
Connecticut Children's Medical Center
Hartford, Connecticut

Jonathan Paul Manley, MBBS, BSc, MRCS
Specialist Registrar
Department of Urology
Bristol Urological Institute
Southmead Hospital
Bristol, United Kingdom

Roy Mano, MD
Research Fellow, Urological Oncology
Department of Surgery, Urology Service
Memorial Sloan Kettering Cancer Center
New York, New York

Stephen Mark, FRACS(Urol)
Clinical Lecturer
Department of Urology
Otago University
Consultant Urologist
Department of Urology
Christchurch Hospital
Christchurch, New Zealand

David T. Marshall, MD, MS
Professor
Radiation Oncology and Urology Department
Medical University of South Carolina
Deputy Associate Director for Clinical Investigations
Hollings Cancer Center
Charleston, South Carolina

Aaron D. Martin, MD, MPH
Assistant Professor
Department of Urology
Louisiana State University
Pediatric Urologist
Department of Surgery
Children’s Hospital
New Orleans, Louisiana

Surena F. Matin, MD
Professor
Department of Urology
Medical Director
Minimally Invasive New Technology in Oncologic Surgery
University of Texas MD Anderson Cancer Center
Houston, Texas

Irene M. McAleer, MD, JD, MBA
HS Associate Clinical Professor
Department of Urology
University of California
Irvine, California

Jack W. McAninch, MD, FACS, FRCS(Eng)(Hon)
Professor of Urology
Department of Urology
The University of California, San Francisco
San Francisco General Hospital
San Francisco, California

Kurt McCammon
Assistant Professor and Program Director
Department of Urology
Eastern Virginia Medical School
Norfolk, Virginia

Christopher D. McClung, MD
Assistant Professor
Department of Urology

The Ohio State University Medical Center
Columbus, Ohio

Leslie T. McQuiston, MD
Private Practice
Children's Urology
Staff Pediatric Urologist
Dell Children's Medical Center of Central Texas
Austin, Texas

Akanksha Mehta, MD, PhD
Assistant Professor
Department of Urology
Emory University School of Medicine
Atlanta, Georgia

Charles Metcalfe, MD
Robotic, Advanced Laparoscopy, and Endourology Fellow
University of Southern California Institute of Urology
Fellow
Department of Urology
University of Southern California
Los Angeles, California

Rosalia Misseri, MD
Associate Professor
Department of Urology
Indiana University School of Medicine
Staff Pediatric Urologist
Department of Pediatric Urology
Riley Hospital for Children at Indiana University Health
Indianapolis, Indiana

Stephen Mock, MD
Fellow
Urologic Surgery
Vanderbilt University Medical Center
Nashville, Tennessee

Jeffrey S. Montgomery, MD, MHSA
Associate Professor
Department of Urology
University of Michigan
Ann Arbor, Michigan

Allen F. Morey, MD, FACS
Professor

Department of Urology
UT Southwestern Medical Center
Dallas, Texas

Todd M. Morgan, MD
Assistant Professor
Department of Urology
University of Michigan
University of Michigan Health System
Ann Arbor, Michigan

Ryan L. Mori, MD, MS
Director, Genitourinary Reconstructive and Prosthetic Surgery
Department of Urology
Geisinger Medical Center
Danville, Pennsylvania

Stephen Y. Nakada
The David T. Uehling Professor of Urology
Chairman, Division of Urology
UW Madison School of Medicine and Public Health
Madison, Wisconsin

Darius A. Paduch, MD, PhD
Associate Professor of Urology and Reproductive Medicine
Department of Urology
Weill Cornell Medical College
Director Sexual Health and Medicine
Department of Urology
Weill Cornell Medical College/New York-Presbyterian Hospital
New York, New York

Neal Patel, MD
Urology Resident
Department of Surgery, Division of Urology
Robert Wood Johnson Medical School
Robert Wood Johnson University Hospital
New Brunswick, New Jersey

Frank J. Penna, MD
Fellow in Pediatric Urology
The Hospital for Sick Children
University of Toronto
Toronto, Ontario, Canada

Kenneth M. Peters, MD
Professor and Chairman

Department of Urology
Oakland University William Beaumont School of Medicine
Rochester Hills, Michigan
Chair
Department of Urology
Beaumont Health System
Royal Oak, Michigan

Jonathan C. Picard, MD
Urologic Surgeon
Roper St. Francis Hospital
Charleston, South Carolina

Eugene J. Pietzak, PhD
Urologic Oncology Fellow
Department of Urologic Surgery
Memorial Sloan Kettering Cancer Center
New York, New York
Chief Resident
Division of Urology
University of Pennsylvania Health Care System
Philadelphia, Pennsylvania

Hans G. Pohl, MD
Associate Professor
Department of Urology and Pediatrics
George Washington University School of Medicine
Associate Chief
Division of Urology
Children's National Medical Center
Washington, DC

John C. Pope IV, MD, FAAP
Professor
Department of Urologic Surgery and Pediatrics
Vanderbilt University Medical Center
Professor
Department of Pediatric Urology
Monroe Carell Jr. Children's Hospital at Vanderbilt
Nashville, Tennessee

Sandip M. Prasad, MD, MPhil
Assistant Professor
Department of Urology
Medical University of South Carolina
Charleston, South Carolina

Daniel Ramirez, MD
Fellow
Glickman Urology and Nephology Institute
Cleveland Clinic
Cleveland, Ohio

Nate Readal, MD
Urology Resident
James Buchanan Brady Department of Urology
The Johns Hopkins Medical Institutions
Baltimore, Maryland

Polina Reyblat, MD
Urologist
Department of Urology
Kaiser Permanente
Los Angeles Medical Center
Los Angeles, California

W. Stuart Reynolds, MD, MPH
Assistant Professor
Department of Urologic Surgery
Vanderbilt University
Nashville, Tennessee

Leslie M. Rickey, MD, MPH
Assistant Professor
Departments of Urology and Obstetrics, Gynecology & Reproductive Sciences
Yale University
Urogynecology & Reconstructive Pelvic Surgery
Yale New Haven Hospital
New Haven, Connecticut

Hubertus Riedmiller
Professor and Chairman
Department of Urology and Pediatric Urology
Julius Maximilians-University Medical School
Wurzburg, Germany

Michael Rink, MD, FEBU
Department of Urology
University Medical Center Hamburg-Eppendorf
Hamburg, Germany

Richard C. Rink, MD FAAP, FACS
Robert A. Garrett Professor Pediatric Urology
Riley Hospital for Children

Indiana University School of Medicine
Indianapolis, Indiana

Chad R. Ritch, MD, MBA
Assistant Professor
Urology Department
University of Miami, Miller School of Medicine
Urology Department
UM-Jackson Memorial Hospital
Miami, Florida

Michael L. Ritchey, MD
Professor
Department of Urology
Mayo Clinic Arizona
Scottsdale, Arizona

Daniel I. Rosenstein, MD, FACS, FRCSC
Clinical Associate Professor
Department of Urology
Stanford University
Associate Chief
Division of Urology
Santa Clara Valley Medical Center
Palo Alto, California

Stephan Roth, MD
Professor and Chairman
Department of Urology and Pediatric Urology
University of Witten/Herdecke
Witten, Germany

Agustín R. Rovegno, MD
Professor
Department of Surgery
Chief
Urology Section
CEMIC
Buenos Aires, Argentina

Eric S. Rovner, MD
Professor of Urology
Attending Staff
Department of Urology
Medical University of South Carolina
Charleston, South Carolina

Edward W. Rowe, BSc (Hons), MD, FRCS (Urol)
Consultant Urological Surgeon
Department of Urology
Bristol Urological Institute
Bristol, England

H. Gil Rushton, MD
Chief, Division of Pediatric Urology
Children's National Medical Center
Professor of Urology and Pediatrics
The George Washington University School of Medicine
Washington, DC

Paul Russo, MD, FACS
Professor
Department of Urology
Weill Cornell School of Medicine
Memorial Sloan Kettering Cancer Center
Professor of Urology
Attending Surgeon
Department of Surgery, Urology Service
Memorial Sloan Kettering Cancer Center
New York, New York

Rafael Sanchez-Salas, MD
Staff Surgeon
Department of Urology
Institut Mutualiste Montsouris
Paris, France

Jay I. Sandlow, MD
Professor
Department of Urology
Medical College of Wisconsin
Vice-Chair
Department of Urology
Froedtert and the Medical College of Wisconsin
Milwaukee, Wisconsin

Richard A. Santucci, MD, FACS, HON FC Urol(SA)
Clinical Professor
Department of Urology
Michigan State College of Osteopathic Medicine
Specialist-in-Chief
Department of Urology
The Detroit Medical Center
Detroit, Michigan

Douglas S. Scherr, MD
Associate Professor of Urology
Department of Urology
Weill Medical College of Cornell University
Clinical Director, Urologic Oncology
Department of Urology
New York-Presbyterian Hospital
New York, New York

Peter N. Schlegel, MD
James J. Colt Professor and Chairman
Department of Urology
Weill Cornell Medical College
Urologist-in-Chief
New York-Presbyterian Hospital
Weill Cornell Medical Center
New York, New York

Megan S. Schober, MD, PhD
Pediatric Urology Fellow
Department of Urology
Nationwide Children's Hospital
Columbus, Ohio

Fernando P. Secin, MD
Associate Professor of Urology
Surgery Department
San Lazaro Foundation
Staff Urologist
Surgery Department
CEMIC University Hospital
Buenos Aires, Argentina

Joel Sheinfeld, MD
Deputy Chief, Urology Service
William G. Cahan Chair in Surgery
Memorial Sloan-Kettering Cancer Center
New York, New York

Mark Sigman, MD
Krishnamurthi Professor and Chief of Urology
Department of Surgery (Urology)
Warren Alpert Medical School of Brown University
Chief of Urology
Department of Surgery (Urology)
Rhode Island Hospital, the Miriam Hospital
Providence, Rhode Island

Jonathan L. Silberstein, MD
Assistant Professor of Urology
Chief, Section of Urologic Oncology
Tulane University School of Medicine
Department of Urology
New Orleans, Louisiana

Jay Simhan, MD
Assistant Professor
Department of Urology
Fox Chase Cancer Center
Temple University School of Medicine
Director of Genitourinary Reconstruction and Prosthetics
Department of Urology
Einstein Healthcare Network/Temple University
Health System
Philadelphia, Pennsylvania

Sri Sivalingam, MD, MSc, FRCSC
Staff Urologist
Department of Urology
Glickman Urological and Kidney Institute
Cleveland Clinic
Cleveland, Ohio

Ariana L. Smith, MD
Assistant Professor
Department of Urology
University of Pennsylvania
Director of Pelvic Medicine and Reconstructive Surgery
Department of Urology
University of Pennsylvania Health System
Philadelphia, Pennsylvania

Douglas G. Stein, MD
Director of Development
No-Scalpel Vasectomy International, Inc.
Naples, Florida
Attending Staff
Division of Surgical Specialties
Florida Hospital Tampa
Tampa, Florida

Urs E. Studer, MD
Professor
Expert Consultant
Department of Urology

University Hospital Bern
Bern, Switzerland

Eva Marie Suarez, MD
Resident Physician
Department of Radiation Oncology
Medical University of South Carolina
Charleston, South Carolina

Cigdem Tanrikut, MD
Assistant Professor of Surgery (Urology)
Department of Urology
Harvard Medical School
Director, Male Reproductive Medicine
Department of Urology
Massachusetts General Hospital
Boston, Massachusetts

Timothy J. Tausch, MD
Fellow, Trauma, Reconstruction and Prosthetics
Assistant Instructor
Department of Urology
UT Southwestern Medical Center
Dallas, Texas

Christopher F. Tenggardjaja, MD
Urology Department
Kaiser Permanente
Los Angeles, California

Joachim W. Thüroff, MD
Professor
Department of Urology
Johannes Gutenberg University
Chairman
Department of Urology
University Medical Center
Mainz, Germany

Jeremy Tonkin, MD
Department of Urology
Eastern Virginia Medical School
Norfolk, Virginia

Eric G. Treat, MD
Clinical Instructor
Department of Urology

David Geffen School of Medicine at UCLA
Department of Urology
UCLA Ronald Reagan Medical Center
Los Angeles, California

Hari S. G. R. Tunuguntla, MD, MS, MCh
Associate Professor of Urological Surgery
Director, Voiding Dysfunction, Urogenital Reconstruction, Neuro Urology, Female Pelvic Medicine and Reconstructive Surgery, and Urodynamics
Rutgers, The State University of New Jersey
Attending Urologist
Director of Voiding Dysfunction, Urogenital Reconstruction, Neuro Urology, Female Pelvic Medicine and Reconstructive Surgery, and Urodynamics
Department of Urology
Robert Wood Johnson University Hospital
New Brunswick, New Jersey

Kristin C. Turza, MD
Resident Physician/Surgery Resident
General Surgery Department
University of Virginia
Charlottesville, Virginia

Mark D. Tyson, MD
Resident
Department of Urology
Mayo Clinic Arizona
Scottsdale, Arizona

Burkhard Ubrig, MD
Associate Professor
Department of Urology
University of Witten/Herdecke
Witten, Germany
Chief
Department of Urology
Augusta Kranken Anstalt
Bochum, Germany

Sandip Vasavada, MD
Associate Professor
Glickman Urology Institute
Urologic Director, Center for Female Pelvic Medicine and Reconstructive Surgery
Department of Urology
Cleveland Clinic
Cleveland, Ohio

Ramón Virasoro, MD
Assistant Professor
Department of Urology
Eastern Virginia Medical School
Virginia Beach, Virginia

Gavin N. Wagenheim, MD
Resident
Division of Urology, Department of Surgery
The University of Texas at Houston Medical School
Houston, Texas

Jonathan N. Warner, MD
Assistant Professor
Department of Urology
University of Michigan
Department of Surgery
VA Hospital of Ann Arbor
Ann Arbor, Michigan

Alon Z. Weizer, MD, MS
Associate Professor
Department of Urologic Oncology
Cancer Center Medical Director
University of Michigan Cancer Center
Ann Arbor, Michigan

Hunter Wessells, MD, FACS
Professor and Nelson Chair
Department of Urology
University of Washington
Chair
Department of Urology
UW Medicine
Seattle, Washington

O. Lenaine Westney, MD
Associate Professor
Department of Urology
MD Anderson Cancer Center
Houston, Texas

Michael B. Williams, MD, MS
Assistant Professor
Department of Urology
Eastern Virginia Medical School
Norfolk, Virginia

J. Stuart Wolf, Jr., MD, FACS
The David A. Bloom Professor
Department of Urology
University of Michigan Medical School
Associate Chair for Surgical Services
Department of Urology
University of Michigan Health Center
Ann Arbor, Michigan

Matthew Wosnitzer, MD
Instructor/Male Reproductive Medicine and Microsurgery Fellow
Center for Male Reproductive Medicine and Microsurgery
Weill Cornell Medical College
New York-Presbyterian Hospital
New York, New York

Musaab Yassin, MB ChB, MRCS(Edn)
Clinical Research Fellow in Incontinence and Urodynamics
Department of Urology
Bristol Urological Institute
Urodynamic Unit—Urology
Southmead Hospital
Bristol, United Kingdom

Ezekiel E. Young, MD, MA
Fellow of Pediatric Urology
The James Buchanan Brady Urological Institute
Johns Hopkins Medical Institutions
Baltimore, Maryland

Richard N. Yu
Instructor
Department of Surgery
Harvard Medical School
Associate
Department of Urology
Boston Children’s Hospital
Boston, Massachusetts

Mark R. Zaontz
Clinical Professor of Urology
Department of Urology
Temple University School of Medicine
Philadelphia, Pennsylvania
Head, Section of Pediatric Urology
Departments of Surgery and Pediatrics
Virtua Health System

Voorhees, New Jersey

Jack M. Zuckerman, MD
Fellow
Department of Urology
Eastern Virginia Medical School
Norfolk, Virginia

REMEMBRANCES

Dr. James F. Glenn MD, FACS, FRCS (Hon)

Pioneer in urology, leader, surgeon, scientist, mentor, and friend—all these describe James F. Glenn's life as a leader in academic medicine. Jim was born in Lexington, Kentucky, on May 10, 1928 and died in Lexington on June 10, 2009. After graduation from the University School in Lexington, Jim studied at the University of Rochester where he graduated with a bachelor of arts degree in 1949. He was accepted at and entered the Duke University School of Medicine graduating with honors in 1952 where he was elected a member of Alpha Omega Alpha. After completion of 2 years as a surgical house officer at the Peter Bent Brigham Hospital in Boston, he returned to North Carolina as a U.S. air force flight surgeon commanding the 3308th hospital. He was influenced by Dr. Edwin Alyea and Dr. John Dees to return to Duke as a urology resident completing his training in urology in 1959. Jim was asked to stay as a faculty member but recalls that he wanted to "spread my wings" and accepted a faculty position at Yale. Following 2 years on the Yale faculty, he once again returned to North Carolina joining William Boyce at Wake Forest as an associate professor.

When Dr. Edwin Alyea chose to step down as Duke's chief of urology, Jim Glenn was chosen as his successor at age 34, then the youngest chief of urology in the country. Once at Duke, Jim blossomed into the leader and mentor that set the course for his career. With his prodigious energy and unconquerable spirit, Jim created one of the most outstanding urology programs in the United States. Known for research, training and clinical excellence, and a reputation that he established continues today. He created an active alumni network called Duke Youthful Society of Urology Residents Interested in Advancement (DYSURIA). He recognized the acute needs of academic programs for philanthropy and created Committee for Urologic Research, Education and Development (CURED) and raised an endowment to fund urologic research and education. He was among the first to recognize the need for educating community urologists and created a regional meeting and quarterly visiting professors open to all urologists in the community. Jim was editor of *Glenn's Urologic Surgery*, now in its eighth edition; it continues to guide both urology trainees and practitioners in surgical procedures from simple to complex.

One of his greatest contributions was his mentorship ability. He was the "godfather" to countless urologists in private practice and academic positions. He trained and mentored future chairs and chiefs at University of Chicago, Emory, Duke, University of North Carolina, University of California-Davis, University of South Florida, and the National Cancer Institute. He also trained chiefs of pediatric urology at Mayo Clinic, Texas Children's Hospital, DuPont Hospital for Children-Jacksonville, and the University of Cincinnati. In his essay for a Duke alumni publication, he stated, "We were a coherent and cohesive coterie of friends, a family with unified goals."

In 1980, Jim moved from urology to academic administration accepting the position as dean of the Emory University School of Medicine where he was instrumental in choosing many clinical chairs and expanding the facilities and research funding. He then moved to the Mount Sinai School of Medicine in New York where he served as president of the Mount Sinai Medical Center from 1983 until 1987. After leaving Mount Sinai, he returned to his home town of Lexington, Kentucky, and served in positions at the University of Kentucky Medical Center including executive director of the Markey Cancer Center (1989–1993), interim chair of the department of surgery (1996–1997), and associate dean for clinical affairs and chief of staff (1993–1995). He served his community as board chairman of the Lexington Cardinal Hill Rehabilitation Hospital and was chair of the Lexington History Museum Board. He funded the Glenn Building at Transylvania College and endowed professorships in urology at the University of Kentucky and Duke University.

Including the American Surgical Association, Jim was a member and officer of many prestigious national and international organizations. He was founding member and president of the Society of University Urologists and president of the Southeastern Section of the American Urological Association, American Association of Genitourinary Surgeons, Clinical Society of Genitourinary Surgeons, Society for Pediatric Urology, The Society of Pelvic Surgeons, and Société Internationale d'Urologie. His honors include the medal of the Société Internationale d'Urologie, its highest honor, Hugh Hampton young award from the American Urological Association as well as its lifetime achievement award. He was honored by the British Association of Urological Surgeons with the St. Paul's Medal for professional contributions and was an honorary fellow of The Royal College of Surgeons of England.

All of these positions and honors, however, do not define the man. Jim Glenn was a caring but focused leader. His humor was legendary. No one who knew Jim could forget the lengthy jokes and humorous stories that he told at many events and the singing of his presidential address at the Clinical Society of Genitourinary Surgeons. His humorous approach to even the most difficult situations put his peers and understudies at ease and demonstrated his ability reach all people. Jim was the consummate mentor. He continued to support, promote, and advise his former residents, faculty, and friends throughout their careers. His steadfast support and sage advice were his lasting legacy.

Culley C. Carson III, MD

PREFACE

The preface for the last edition (seventh) of *Glenn's Urologic Surgery* was written by Dr. Glenn shortly before his death. Having reviewed it with a view to making changes, I find that there are none to make. He said all that needed to be said, and therefore, both Sam and I feel we have no more to add. Enjoy!

Tom Keane, MD, BCh, FRCSI, FACS

In 1969 when the first edition of *Urologic Surgery* was published, the avowed purpose of the work was to present authoritative expositions of various surgical procedures, authored by acknowledged experts in the field. It was the conviction of the editors that there were atlases and textbooks that presented urology well, but there were no volumes on surgical technique, and that urology is—first and foremost—a surgical specialty.

In developing that initial effort, I was joined (and guided) by my good friend and wise mentor William H. Boyce, superb clinician, outstanding scientist, and master surgeon. Between us, we were able to recruit some of the most respected urologic surgeons to contribute to the volume. Over the years, that tradition has continued, and I am forever grateful to all of my colleagues who have given of their time, talent, and expertise to the several iterations of this book.

Having observed my 81st birthday and retired from active clinical practice, I recognize that the time has come to pass the responsibility to others, and I happily do so. Two friends—Sam D. Graham Jr., MD, former Chairman of Urology at Emory University and former Director of the Johns Cancer Center in Richmond, Virginia, and Thomas E. Keane, MD, Chairman of Urology at the Medical University of South Carolina, Charleston—have already demonstrated their proficiency in co-editing previous editions. Both Dr. Graham and Dr. Keane are products of the Duke system, as I am.

As our French friends say, "Vive urologie!"

James F. Glenn, BA, MD, DSc, FACS, FRCS

CONTENTS

Editors
Contributors
Remembrances
Preface

SECTION I

ADRENAL, RENAL, URETER, PELVIS

Jerome P. Richie

1 Anatomy of the Adrenal Glands, Kidney, Ureter, and Pelvis
Kristin C. Turza and Sam D. Graham, Jr.

2 Open Partial Nephrectomy
Paul Russo, Roy Mano, and Simon Kimm

3 Radical Nephrectomy
Chad R. Ritch, Sam S. Chang, and Michael S. Cookson

4 Intracaval Tumors
William C. Faust and John A. Libertino

5 Donor Nephrectomy: Laparoscopic Techniques
Jim C. Hu and Eric G. Treat

6 Laparoscopic/Robotic Nephrectomy and Partial Nephrectomy
Jean-Christophe Bernhard, Charles Metcalfe, and Inderbir S. Gill

7 Minimally Invasive Nephroureterectomy
Alon Z. Weizer and Jeffrey S. Montgomery

8 Laparoscopic Renal Procedures: Renal Cystectomy, Biopsy, and Nephropexy
Michael Maddox and Benjamin R. Lee

9 Laparoscopic Ablation of Small Renal Masses
Daniel Ramirez and Jeffrey A. Cadeddu

10 Laparoscopic and Robotically Assisted Pyeloplasty in Adults
J. Stuart Wolf, Jr.

11 Laparoscopic Adrenalectomy
Arvin K. George and Louis R. Kavoussi

12 Renal Trauma
Jill C. Buckley and Jack W. McAninch

13 Renal Transplantation
John M. Barry

14 Ureteric Complications Following Kidney Transplantation
H. Albin Gritsch and Eric G. Treat

15 Renal Autotransplantation
Venkatesh Krishnamurthi and David A. Goldfarb

16 Miscellaneous Laparoscopic Urologic Procedures: Lymphoceles, Calculus, Varicocele, Ureterolysis
Sri Sivalingam, Sean P. Hedican, and Stephen Y. Nakada

SECTION II
BLADDER

Stephen J. Savage

17 Anatomy of the Bladder
Clinton W. Collins and Adam P. Klausner

18 Simple and Partial Cystectomy
Ryan S. Levey and Jonathan C. Picard

19 Radical Cystectomy in Men
Mohamed A. Ghoneim and Ahmed M. Harraz

20 Radical Cystectomy in Women
Miriam Hadj-Moussa, Joanne Lundgren, Cheryl T. Lee, and Todd M. Morgan

21 Bladder Diverticulectomy
Sarah Fraumann Faris and Sam S. Chang

22 Bladder Augmentation
Stephen Mark

23 Management of the Distal Ureter for Nephroureterectomy
Gavin N. Wagenheim and Surena F. Matin

24 Vesicovaginal Fistula
Hajar I. Ayoub and O. Lenaine Westney

25 Intestinourinary Fistulas
Ryan L. Mori, Eric A. Klein, and Kenneth W. Angermeier

26 Vesical Trauma and Hemorrhage
Chad M. Gridley and Christopher D. McClung

27 Interstitial Cystitis/Bladder Pain Syndrome
Michael J. Ehlert and Kenneth M. Peters

28 Minimally Invasive Bladder Procedures: Radical Cystectomy, Partial Cystectomy, Urachal Excision, Diverticulectomy
Andre Luis de Castro Abreu, Sameer Chopra, and Inderbir S. Gill

SECTION III
PROSTATE

Sandip M. Prasad

29 Anatomy of the Prostate
Jonathan Paul Manley, Edward W. Rowe, and Christian Andreas Bach

30 Surgery for Benign Prostatic Obstruction
Musaab Yassin, Sandip M. Prasad, and Hashim Hashim

31 Open Radical Retropubic Prostatectomy
David Gillatt and Sandip M. Prasad

32 Radical Perineal Prostatectomy
Sam D. Graham, Jr. and Thomas E. Keane

33 Robotically Assisted Laparoscopic Radical Prostatectomy
Sandip M. Prasad, David Gillatt, and Magnus Annerstedt

34 Brachytherapy for Localized Prostate Cancer
Eva Marie Suarez, Harry S. Clarke, and David T. Marshall

35 Imaging, Innovation, and Novel Therapies
Andrew D. Hardie, G. Joel DeCastro, and Sandip M. Prasad

SECTION IV
URETHRA

Eric S. Rovner

36 Anatomy of the Urethra
Lawrence M. Dagrosa and E. Ann Gormley

37 Female Urethral Reconstruction for Fistula and Female Urethral Diverticulum
Ahmed M. El-Zawahry and Eric S. Rovner

38 Surgical Management of the Incompetent Bladder Outlet in the Patient with a Neurogenic Bladder
Teresa L. Danforth and David A. Ginsberg

39 Anterior Urethral Stricture Disease
Hunter Wessells

40 Surgery for Urethral Trauma Including Urethral Disruption
Timothy J. Tausch, Jay Simhan, and Allen F. Morey

41 Carcinoma of the Urethra (Male and Female)
Eugene J. Pietzak and Thomas J. Guzzo

42 Injectable Therapies for Incontinence in Women
Stephen Mock, Melissa R. Kaufman, W. Stuart Reynolds, and Roger R. Dmochowski

43 Urethral Slings
Alex Gomelsky

44 Abdominal Retropubic Approaches for Female Incontinence
Leslie M. Rickey

45 The Artificial Urinary Sphincter
Angelo E. Gousse, Hari S. G. R. Tunuguntla, Neal Patel, and Izak Faiena

46 The Male Sling for Postprostatectomy Incontinence: Current Concepts and Controversies
Ying H. Jura and Craig V. Comiter

47 Sacral Neuromodulation
Christopher F. Tenggardjaja and Sandip Vasavada

48 Surgical Treatment of Pelvic Organ Prolapse
Ariana L. Smith, Polina Reyblat, and Ja-Hong Kim

SECTION V
TESTIS, EPIDIDYMIS, VAS DEFERENS, AND SEMINAL VESICLES

Marc Goldstein

49 Anatomy of the Epididymis, Vas Deferens, and Seminal Vesicle
Akanksha Mehta

50 Seminal Vesicle and Ejaculatory Duct Surgery
Brooke A. Harnisch and Jay I. Sandlow

51 Vasectomy
Douglas G. Stein

52 Vasovasostomy and Vasoepididymostomy

Matthew Wosnitzer and Marc Goldstein
53 Microsurgical Varicocelectomy
Marc Goldstein
54 Epididymectomy
Khalid Alrabeeah and Peter Chan
55 Ejaculation Induction Procedures
Darius A. Paduch, Lindsay Dow, and Robert John Lischer
56 Anatomy of the Testis
Mark Sigman
57 Sperm Retrieval Techniques
Kelly A. Chiles and Peter N. Schlegel
58 Simple Orchiectomy
Jonathan L. Silberstein
59 Radical Inguinal Orchiectomy
Daniel J. Lee and Douglas S. Scherr
60 Organ-Preserving Surgery in Testicular Tumors
Axel Heidenreich
61 Retroperitoneal Lymph Node Dissection
Simon Kimm and Joel Sheinfeld
62 Torsion of the Testicle
Diana K. Bowen and Robert E. Brannigan
63 Scrotal Trauma and Reconstruction
K. Jeff Carney and Gerald H. Jordan

SECTION VI

PENIS AND SCROTUM

Ramón Virasoro

64 Penile and Scrotal Anatomy
Jonathan N. Warner and Richard A. Santucci
65 Partial and Total Penectomy in the Management of Invasive Squamous Cell Carcinoma of the Penis
Fernando P. Secin, Agustín R. Rovegno, Ana María Autrán Gómez, and Rafael Sánchez-Salas
66 Inguinal Lymphadenectomy for Penile Carcinoma
Jack W. Lambert and Michael B. Williams
67 Surgical Treatment of Peyronie’s Disease
Brooke Edwards and Ramón Virasoro
68 Priapism
Arthur L. Burnett II and Nate Readal
69 Penile Prosthesis Implantation
Robert M. Coward and Culley C. Carson
70 Penile Vascular Surgery
Jack M. Zuckerman and Kurt McCammon
71 Penile Trauma
Judith C. Hagedorn and Daniel I. Rosenstein
72 Penile Replantation
Jairam R. Eswara and Steven B. Brandes
73 Hydrocele and Spermatocele

Ali A. Dabaja and Cigdem Tanrikut

74 Congenital Curvature
Erik Grossgold and Jeremy Tonkin

75 Ileal Conduit Urinary Diversion
Samuel C. Haywood and Eric A. Klein

SECTION VII

URINARY DIVERSION

Urs E. Studer

76 Transverse Colonic Conduit
Michael Rink and Margit Fisch

77 Managing the Patient with Orthotopic Bladder Substitution
Gianluca Giannarini and Urs E. Studer

78 Orthotopic Urinary Diversion Using an Ileal Low-Pressure Reservoir with an Afferent Tubular Segment
Fiona Burkhard and Urs E. Studer

79 Ileal Neobladder
Richard E. Hautmann

80 Colonic Orthotopic Bladder Substitution
Joachim W. Thüroff and Ludger Franzaring

81 Continent Catheterizable Reservoir Made from Ileum
Hassan Abol-Enein and Mohamed A. Ghoneim

82 Continent Catheterizable Reservoir Made from Colon
Hubertus Riedmiller, Elmar W. Gerharz, and Arkadius Kocot

83 Ureterosigmoidostomy and Mainz Pouch II
Michael Rink and Margit Fisch

84 Palliative Urinary Diversion
Stephan Degener, Burkhard Ubrig, and Stephan Roth

SECTION VIII

PEDIATRICS

H. Gil Rushton

85 Wilms Tumor
Mark D. Tyson and Michael L. Ritchey

86 Renal Fusion and Ectopia
Ross M. Decter and Amy S. Burns

87 Transureteroureterostomy
Aaron D. Martin and H. Gil Rushton

88 Pyeloplasty
Megan S. Schober, Kevin M. Feber, and Evan J. Kass

89 Megaureter
Christopher J. Long, J. Christopher Austin, and Douglas A. Canning

90 Prune Belly (Triad) Syndrome
David B. Joseph

91 Childhood Rhabdomyosarcoma
Frank J. Penna and Martin A. Koyle

92 Vesicoureteral Reflux
Mark R. Zaontz and Christopher J. Long

93 Endoscopic Treatment of Vesicoureteral Reflux
Angela M. Arlen and Andrew J. Kirsch

94 Ureteroceles
Richard N. Yu, Chester J. Koh, and David A. Diamond

95 Urachal Anomalies and Related Umbilical Disorders
Leslie T. McQuiston and Anthony A. Caldamone

96 Vesical Neck Reconstruction
John C. Pope IV and John H. Makari

97 Surgery for Posterior Urethral Valves
Rosalia Misseri and Kenneth I. Glassberg

98 Hypospadias
Laurence S. Baskin

99 Complete Primary Repair for Exstrophy
Richard W. Grady

100 Exstrophy and Epispadias—Modern Staged Approach
Ezekiel E. Young, John P. Gearhart, and Brian M. Inoyuye

101 Pediatric Cryptorchidism, Hydroceles, and Hernias
Angela M. Arlen and Christopher S. Cooper

102 Pediatric Laparoscopic and Robotic Pyeloplasty
Pasquale Casale and Walid A. Farhat

103 Pediatric Laparoscopic Nephrectomy and Partial Nephrectomy
Glenn M. Cannon, Jr. and Richard S. Lee

104 Urogenital Sinus and Cloacal Anomalies
Richard C. Rink, Jeffrey A. Leslie, and Martin Kaefer

105 Surgery to Correct Ambiguous Genitalia (46XX Disorder of Sexual Development)
Anthony J. Casale

106 Circumcision, Concealed Penis, and Scrotal Abnormalities
Irene M. McAleer and George W. Kaplan

107 Augmentation Cystoplasty in Children
Nora G. Lee and Hans G. Pohl

108 The Mitrofanoff and Malone Antegrade Continence Enema Procedures in Pediatric Urinary Tract Reconstruction
Mark P. Cain

Index

SECTION I ■ ADRENAL, RENAL, URETER, PELVIS

Section Editor: JEROME P. RICHIE

CHAPTER 1 ■ ANATOMY OF THE ADRENAL GLANDS, KIDNEY, URETER, AND PELVIS

KRISTIN C. TURZA AND SAM D. GRAHAM, JR.

ADRENAL

The adrenal glands are paired and located high in the retroperitoneum, on the anterior craniomedial aspect of the kidney (Figs. 1.1 to 1.3). Distinct in appearance from the surrounding fat and pancreas by their golden color, the adrenals each weigh approximately 4 to 5 g. Glandular weight and size may change with prolonged illness or prolonged adrenocorticotropic hormone (ACTH) stimulation. The atrophic gland is thin and pale compared to the normal or hyperplastic gland. The left gland has a semicircular or crescent shape. The right gland has an inverted pyramidal or V shape. The adrenal gland consists of the cortex and medulla and arise from mesodermal (cortex) and ectodermal (medulla) elements in the medial aspect of the coelomic cavity.

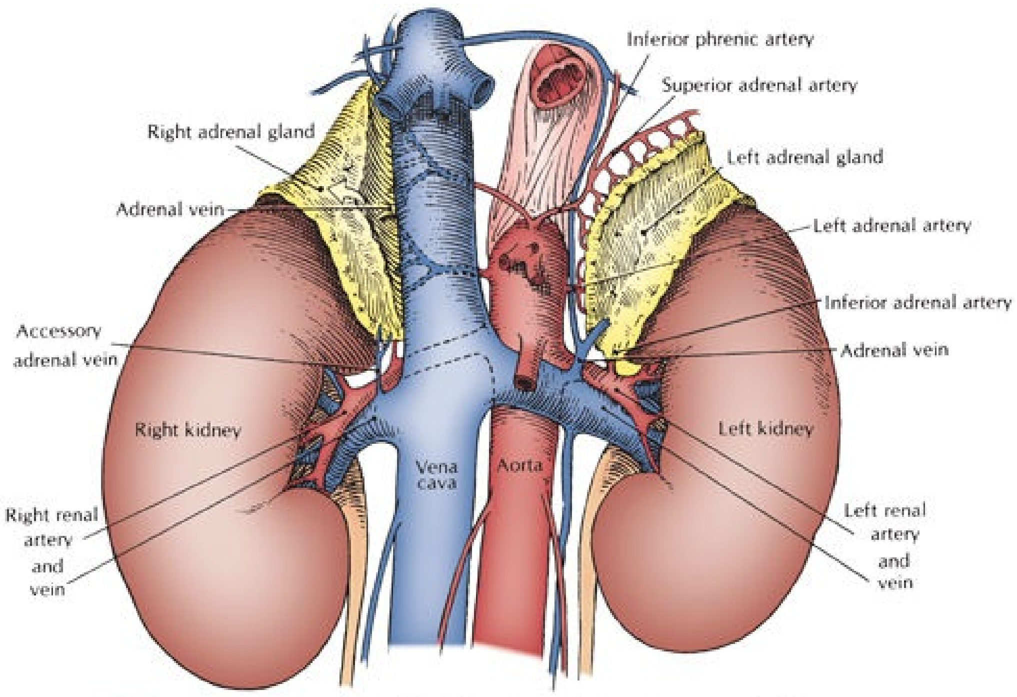

FIGURE 1.1 The anatomic relationship of the adrenal glands to the aorta and inferior vena cava. Multiple arterial vessels entering the glands indicate the rich arterial supply, while a single central adrenal vein illustrates the limited and relatively constant venous damage.

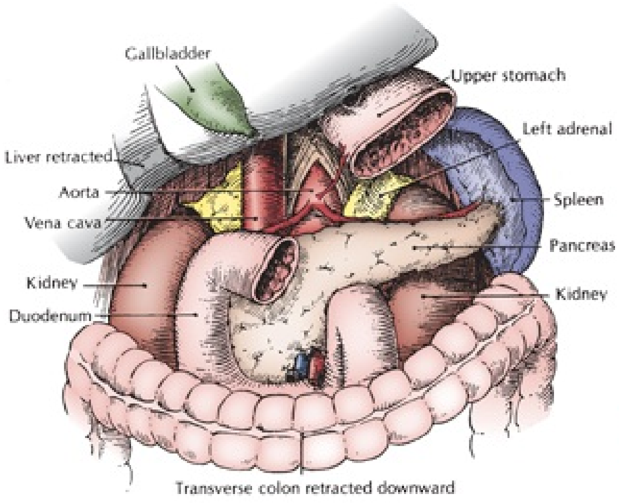

FIGURE 1.2 An anterior view of the abdomen illustrating the anatomic relationship of the adrenal glands to the surrounding gastrointestinal tract and organs.

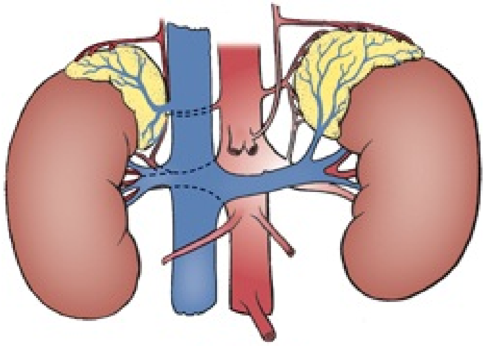

FIGURE 1.3

Embryology

The cortex and medulla each have a unique embryologic derivation. The coelomic mesoderm, specifically the dorsal cells of the blastema cord at the medial aspect of the mesonephric bodies, gives rise to the cortex. Of note, the ventral cells of these bodies are the origin of the interstitial cells of the testis or the theca cells of the ovary. The medulla is derived from neural crest cells, which migrate from the same primordial neural crest giving rise to the sympathetic chain. The 8-week embryo has massive adrenals, approximately the size of the kidney, and they remain enlarged and very vascular until birth. Rapid regression occurs in the adrenal size during the first month. The large adrenal size with hypervascularity may predispose to adrenal hemorrhage in the newborn as well as misdiagnosis for Wilms tumor or neuroblastoma. The medullary tissue within the gland imparts a unique tripartite structure of the head (most medial), body, and tail (most lateral). Each adrenal gland resides within the Gerota fascia with the kidney. However, in the case of renal ectopy, the adrenal remains in its natural position.

Ectopic adrenal tissues may develop in certain locations of the body. Although rare, they may undergo neoplastic changes or hyperplasia. Ectopic adrenal tissues in most cases consist of cortex only; rarely do they contain cortex and medulla. The embryologic relationship in the urogenital ridge predisposes to adrenal ectopy in the retroperitoneum, the testis, the spermatic cord, and the region of the celiac ganglion.

Vascular Anatomy

The arterial supply remains variable; the main sources include primarily the branches from the aorta, inferior phrenic artery, and renal artery. The multiple small-caliber arterial branches must be appreciated for hemostasis during surgery. Controlling the venous drainage, although less variable, can be challenging, especially when operating on large adrenal masses, which may obscure visualization. The right adrenal vein is short and empties directly into the inferior vena cava (IVC) in its most posterolateral aspect. Bleeding from this site can be profuse and even life-threatening if not identified and controlled immediately. The left adrenal vein comparatively is smaller than the right and exits anteroinferiorly, draining into the ipsilateral renal vein.

Contiguous Structures

Preventing intraoperative injury to contiguous structures rests on the surgeon having a thorough knowledge of the anatomic relationships of the adrenal gland (see Fig. 1.2). The right adrenal gland lies superior to the upper pole of the right kidney, posterolateral to the IVC. Dissection of the right adrenal gland is limited medially by the duodenum and superiorly by the right hepatic lobe. Access to the right adrenal gland is more easily obtained by entering the retroperitoneum behind the liver. The right hepatic lobe can be mobilized from the colon and diaphragm by transecting the triangular, coronary, and hepatocolic ligaments, allowing visualization of the right adrenal gland just superior to the upper pole of the right kidney. Mobilization of the duodenum is also required for easier identification of the right adrenal vein. This step is critical when resecting large pheochromocytomas because early access to the adrenal vein is essential. Using the Kocher maneuver, the duodenum can be retracted medially, enabling access to the IVC and thorough dissection of the right adrenal vein. With the right adrenal vein controlled, an avascular plane is developed laterally on the gland resulting in quick and bloodless removal. The main arterial trunks and small-caliber arteries can be easily controlled with electrocautery and/or surgical clips.

The left adrenal gland is usually more medial than the right, and it lies on the upper pole of the left kidney, just lateral to the aorta. The left adrenal gland lies in close contact with the spleen and stomach, and it is crossed on its anteroinferior surface by the body of the pancreas and splenic artery and vein. A special technical effort must be made to prevent inadvertent injury to the tail of the pancreas and/or capsule of the spleen. Releasing the splenocolic ligament allows free mobilization of the spleen, and gentle blunt dissection allows medial mobilization of the left abdominal viscera and adequate exposure of the left adrenal gland. The left adrenal vein is usually isolated in the anteroinferior aspect of the gland, and control of this vein is usually less of a problem, with minimal blood loss (see Fig. 1.3). The lowest extent of this gland is close to the renal vessel, which remains at risk of injury during adrenalectomy.

KIDNEY

The abdominal wall is composed of three layers of muscle and fascia that are derived from the same embryonic muscle sheets as the intercostal muscles. Each muscle is invested by its own layer of deep fascia and innervated by intercostal nerves. The external oblique fibers are oriented anteriorly and inferiorly, attaching posteriorly to the iliac crest, and the anterior fibers attach to the linea alba in the midline (Fig. 1.4A). The internal oblique fibers are oriented anteriorly and superiorly (Fig. 1.4B). Posteriorly, the internal oblique fibers attach to the lower four ribs and anteriorly they attach to the linea alba. In the upper abdomen, the internal oblique fascia splits to enclose the rectus muscle, whereas inferiorly, the fascia only covers the rectus muscle anteriorly. The ilioinguinal and iliohypogastric nerves are found in the internal oblique fascia anterior to the internal oblique muscle. The transversus abdominis are horizontally oriented fibers that attach to the linea alba (Fig. 1.4C).

The ribs are supported by the intercostal muscles and fascia, as well as the costovertebral (costotransverse) ligament, which must be divided if the rib is to be retracted inferiorly (Fig. 1.5).

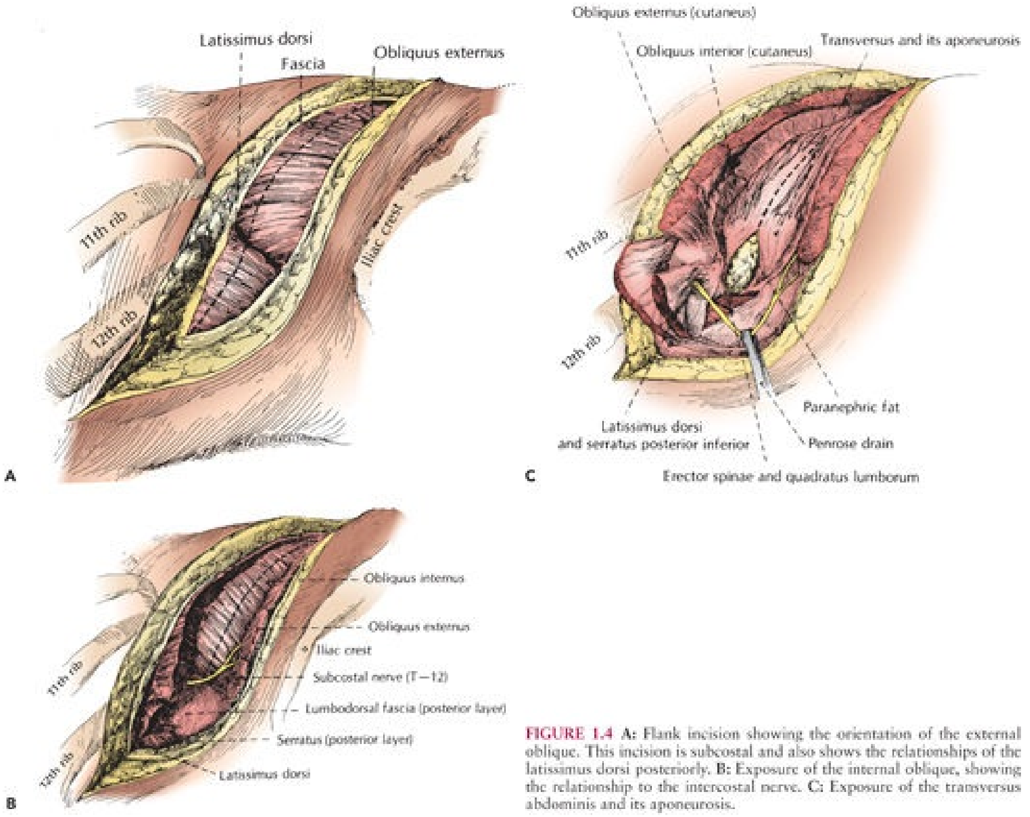

FIGURE 1.4 **A:** Flank incision showing the orientation of the external oblique. This incision is subcostal and also shows the relationships of the latissimus dorsi posteriorly. **B:** Exposure of the internal oblique, showing the relationship to the intercostal nerve. **C:** Exposure of the transversus abdominis and its aponeurosis.

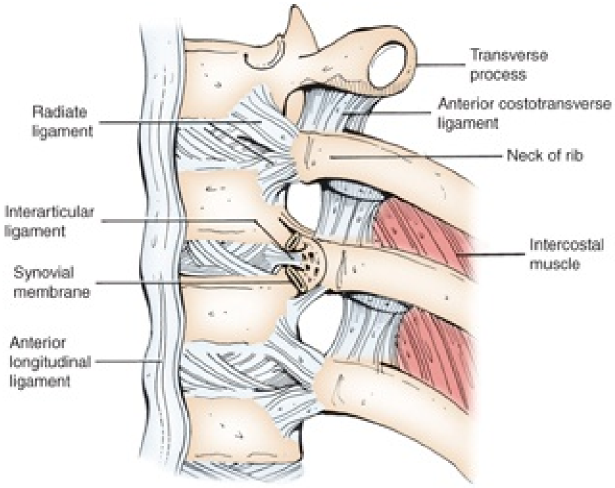

FIGURE 1.5 Costovertebral (costotransverse) ligaments extend from the transverse process of the vertebra immediately above the rib to the neck of the rib. In order to gain exposure during a thoracolumbar or supracostal approach, this must be divided to allow the rib to rotate inferiorly.

The kidneys are located on either side of the vertebral column in the lumbar fossa of the retroperitoneum and vary in length in adults from 11 to 14 cm, or from approximately 3.0 to 4.5 times the height of the second lumbar vertebrae (see Fig. 1.1). A normal adult kidney weighs 135 to 140 g. The right kidney tends to be lower in the retroperitoneum than the left because of the liver's position. The parenchyma of the kidney is covered by a thin transparent capsule, which in turn is covered by a layer of perinephric fat enclosed in a distinct layer of fascia (Gerota fascia) (Fig. 1.6). The capsule is attached to Gerota fascia by fibrous trabeculae (1). Gerota fascia is completely fused superiorly and laterally, but it is open inferiorly and to some extent medially, where it is adherent to the adventitia of the renal vessels, aorta, and IVC. Gerota fascia extends above the kidney to form a special compartment for the adrenal gland (2). Posteriorly, Gerota fascia is connected to the sheaths of the psoas and quadratus lumborum muscles by connective tissue septae. Anteriorly, Gerota fascia is closely applied to the peritoneum. On the left, the hilum of the spleen is attached to the ventral aspect of the kidney by a double layer of peritoneum known as the splenorenal ligament (2).

The kidney contains a cortex and medulla. The cortex is the site of ultrafiltration and erythropoietin production, and it contains renal columns (columns of Bertin) and corpuscles (composed of the glomerulus and Bowman capsule). Columns of Bertin contain renal vessels traversing to the peripheral cortex. This anatomic feature is important during percutaneous collecting system access performed via a posterolateral needle approach into the posterior calyx along Brödel line (avascular plane between the posterior and anterior arterial divisions) through a renal pyramid to avoid potential vascular injury associated with sticking the columns (3). The medulla is not a contiguous layer within the kidney; instead, it is divided into pyramids, consisting of tubules that transport urine from the cortex to the calyces. Nephrons are the basic functional unit of the kidney and consist of a glomerulus and tubules (proximal, distal, and loop of Henle). The nephrons drain into collecting ducts and coalesce ultimately in the ureter.

Vascular Anatomy

The main renal arteries branch from the lateral aorta at approximately L2. Generally, the renal arteries divide into segmental branches at the junction of the middle and final third of their course. A single left artery most commonly lies dorsal to the renal vein, and a long right renal artery lies dorsal to the vena cava and renal vein. Up to 35% of kidneys have an accessory renal artery, with 1.5% having more than one accessory artery (2). As the renal artery approaches the hilum, it has two branches, the inferior suprarenal (adrenal) and the ureteric arteries (Fig. 1.6). At the hilus, the main renal artery divides into an anterior and posterior branch, which further divide into segmental arteries. The kidney can be divided into four segments based on the arterial supply (Fig. 1.7). Both the apical and basilar segmental arteries supply each respective pole of the kidney anteriorly and posteriorly. The largest segment is the anterior segment, which is supplied by two segmental arteries and extends posteriorly to the avascular plane where it meets the posterior segment (4).

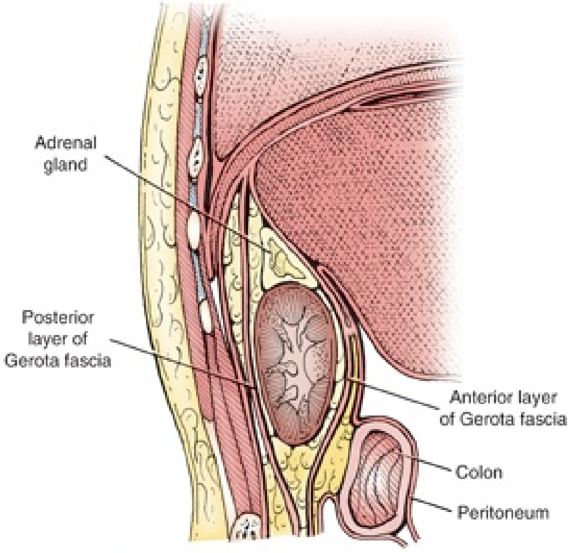
Adrenal gland
Posterior layer of Gerota fascia
Anterior layer of Gerota fascia
Colon
Peritoneum

FIGURE 1.6 Retroperitoneal anatomy showing Gerota fascia in sagittal section.

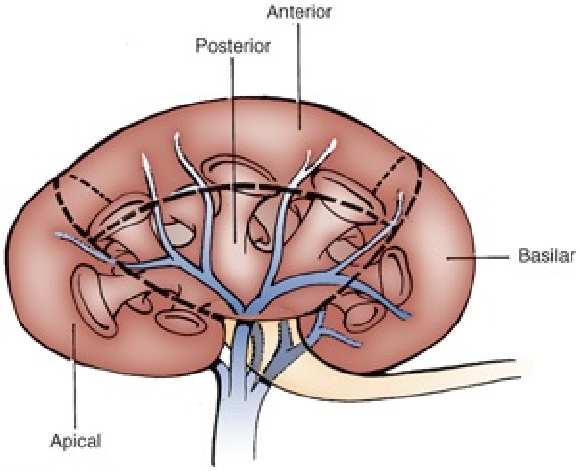

FIGURE 1.7 Segmental anatomy of the kidney. The relatively avascular plane between the anterior and posterior segments is the line of Brödel. In general, calyces tend to extend from the renal pelvis to the central mass of the segment they supply.

The renal veins directly join the vena cava. The right renal vein is usually less than one-half the length of the left renal vein and has no significant branches. The left renal vein, however, is usually joined by the adrenal and inferior phrenic vein superiorly, the gonadal vein inferiorly, and frequently by lumbar vein(s) posteriorly (Fig. 1.8). These collaterals are of great importance in patients in whom the vena caval ligation or resection is contemplated.

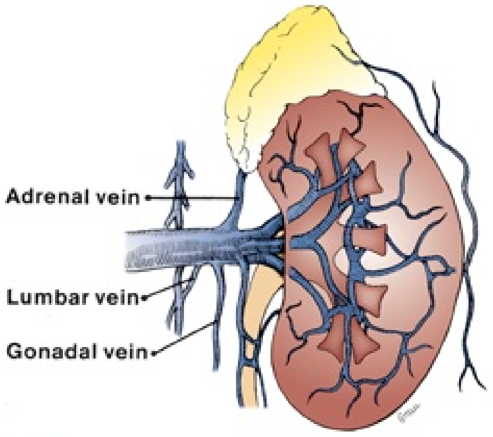

FIGURE 1.8 The complex and varied anatomy of the left renal vein. Note that there may be one or even two lumbar veins from the renal vein posteriorly, allowing alternative venous flow if the vena cava is occluded.

The renal vein is usually the most anterior structure in the renal hilum. Posterior to the vein is the renal artery, and the most posterior structure in the hilum is the renal pelvis. The hilum is filled with fibrofatty tissue that can usually be easily dissected from these structures to allow access into the renal sinus (Fig. 1.9).

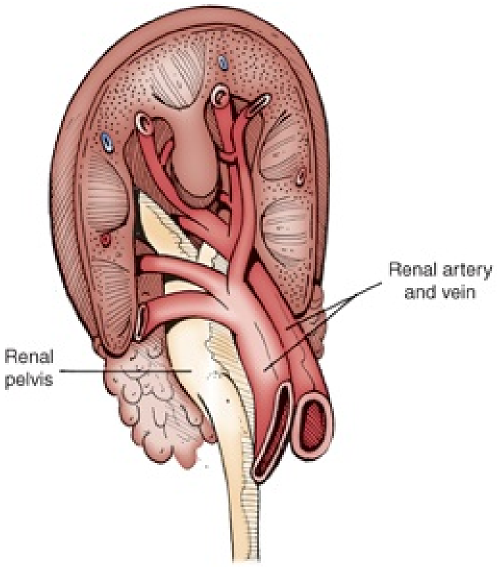

FIGURE 1.9 Transverse section of kidney showing relative anatomy of vascular structures in the renal hilum.

Lymphatic Anatomy

Parenchymal and capsular lymphatics merge and drain into the right lumbar or para-aortic chains, respectively. These lymphatics become part of the cisterna chylae superior to the renal artery.

Nervous Innervation

The kidney is innervated by sympathetic preganglionic fibers from T8 to L1 with subsequent course to the celiac and aorticorenal ganglia. An autonomic plexus surrounds the renal artery and contains postganglionic fibers. Sympathetic efferent fibers reach renal vasculature, tubules, and juxtaglomerular cells. Sympathetic stimulation decreases renal blood flow and glomerular filtration and increases sodium and water absorption and renin production. Fibers from the vagus nerve constitute the parasympathetic innervation and terminate in the same autonomic plexus. Parasympathetic stimulation results in vasodilation.

Contiguous Structures (Fig. 1.10)

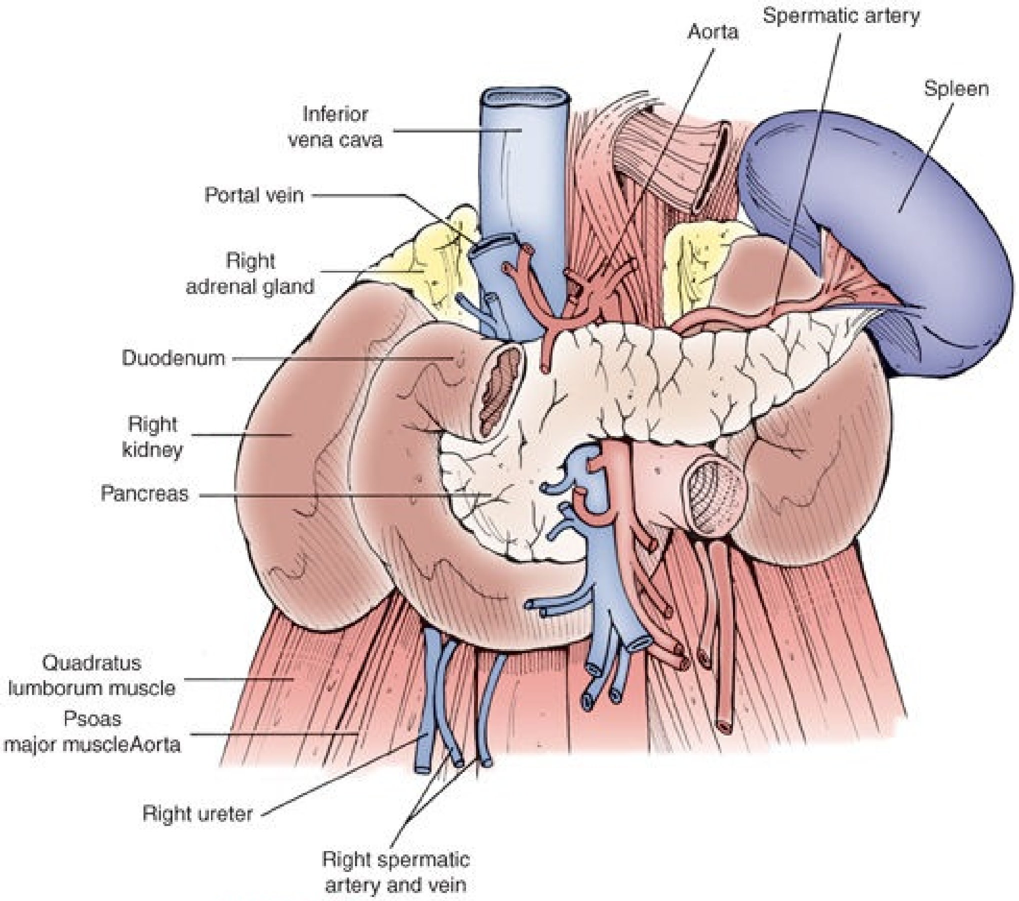

FIGURE 1.10 The kidney in relation to contiguous structures.

Posterior to the kidney lie the psoas major and quadratus lumborum muscles. Posteriorly and superiorly, the upper pole of each kidney is in contact with the diaphragm. The pleura is also adjacent to the upper poles of both kidneys, usually extending down below the level of the 12th rib posteriorly and to the 11th rib anteriorly (1). This is important to bear in mind intraoperatively or during percutaneous procedures because violating the pleural space is a potential complication. With respect to their rotational axis, the lower pole of both kidneys is anteriorly displaced and located lateral to the upper pole.

Embryologically, when the gut rotates, this leaves the posterior parietal peritoneum covering the upper three-fourths of the right kidney, which is directly related to the hepatorenal pouch of Morrison. The duodenum is fixed to the original peritoneal covering of the lower pole of the right kidney by fusion of the embryonic dorsal mesentery to the posterior parietal peritoneum (2). On the left, the rotation of the foregut causes a fusion of the embryonic mesogastrium with the original peritoneal covering of the upper anterior kidney, thereby causing the relationship of the left kidney to the omental bursa (2). The midportion of the left kidney loses its contact with the peritoneum due to growth of the tail of the pancreas.

Superiorly, the anteromedial surface of the right kidney is in contact with the right adrenal gland. The liver overlies the anterior two-thirds of the right kidney, and the hepatic flexure of the colon overlies the lower one-third of the right kidney. The second portion of the duodenum overlies the renal hilum. In >90% of patients, the right kidney is lower than the left (2).

The medial surface of the left kidney is also in contact with the left adrenal gland. Other structures anterior and in close approximation to the left kidney are the spleen, the tail of the pancreas, the stomach, and the splenic flexure of the colon.

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CHAPTER 2 OPEN PARTIAL NEPHRECTOMY

PAUL RUSSO, ROY MANO, AND SIMON KIMM

Over the last 20 years, partial nephrectomy (PN) has emerged as a critical operation for the treatment of renal cortical tumors (1). Advances in complex stone surgery (anatrophic kidney splits, hilar clamping, ice slush, collecting system repair), trauma surgery (renorrhaphy, proximal renal hilar control, vascular repair), and kidney donor transplantation (renoprotective solutions, ice slush) set the stage for the development of contemporary controlled open PN (2,3). The rapid development of the modern imaging modalities of ultrasound, computerized tomography (CT), and magnetic resonance imaging (MRI), often ordered for nonspecific abdominal or musculoskeletal complaints or during unrelated cancer care, leads to the detection of small, asymptomatic renal masses (1), which today account for 70% of all newly diagnosed renal tumors with a median tumor size of <4 cm (T1a). Approximately 20% of these tumors are benign (i.e., oncocytoma, fat poor angiomyolipoma), 25% are indolent malignancies with limited metastatic potential (i.e., papillary type 1, chromophobe, cystic renal cell carcinoma [RCC]), and 54% are the more potentially malignant clear cell carcinoma, but at the T1 size (<7 cm), metastasis would be realized in less than 10% of patients (1). These factors, which when taken together, led to the expansion of elective PN in the late 1990s (4). Once reserved only for the essential indications of tumors in an anatomically or functionally solitary kidney, today PN can effectively achieve the same local tumor control as radical nephrectomy (RN) while maximally preserving renal function and preventing or worsening preexisting chronic kidney disease (CKD) (5). Based on common preexisting medical conditions such as diabetes, hypertension, and cigarette smoking–induced vascular disease, CKD is present in up to 30% of patients with renal cortical tumors prior to operation and is associated with subsequent cardiovascular events, increased rates of hospitalization, and worse overall survival (6). The historical use of RN for all renal tumors, regardless of size, must now be considered obsolete. We have replaced the large and painful 11th rib flank incision associated with flank bulge and hernia in up to 50% of cases (7) with a mini-flank surgical incision (8,9) which, when coupled with our rapid recovery clinical pathway (10), is a highly effective approach to PN and leads to a median 2-day hospital length of stay. This approach is an excellent alternative to the expensive and technically complex minimally invasive (laparoscopic and robotic assisted laparoscopic) PN.

INDICATIONS FOR SURGERY

In the past 20 years, PN has transitioned from an operation only performed for *essential* conditions (tumor in a solitary kidney, bilateral tumors, tumor in patient with preexisting medical disease) to now include *elective* conditions (tumor in a patient with a normal contralateral kidney). Initially, elective PN was restricted to tumors of 4 cm or less (11–13), but with increasing experience, surgeons approached T1b and T2-T3a tumors (14–17) when technically feasible with similar oncologic outcomes compared to RN. With the advantage of intraoperative ultrasound (18), it is now also possible to resect impalpable endophytic, renal sinus, multifocal, and perihilar tumors which previously would have been treated only by RN.

PN may also be advocated as a salvage procedure after failed thermal ablation attempts, as "redo" procedures for recurrent renal tumors in both the sporadic and hereditary RCC setting, and uncommonly as a cytoreductive procedure in metastatic patients with a small renal tumor prior to the initiation of systemic therapy. These indications pose a greater surgical challenge than primary PN with more potential for blood loss and conversion to RN if, for technical reasons, PN cannot be executed. In essence, today, all patients with kidney tumors are scrutinized closely for consideration of PN, and only those where the majority of the kidney is replaced by tumor or those with massive tumors with regional adenopathy and/or renal vein/inferior vena cava extension will undergo RN.

ALTERNATIVE THERAPIES

Patients with small renal tumors are eligible for active surveillance, or surgery (PN or RN) by either open or minimally invasive approaches. In general, for older patients (>75 years) or those with serious medical comorbidities and a limited life expectancy, active surveillance is recommended due to the low likelihood of disease progression in the patient's lifetime and significant risks associated with surgical intervention (19,20). Active surveillance, even with small renal tumors, is more difficult to propose in young and healthy patients with a long life expectancy because on rare occasions, rapid tumor growth and metastatic disease can ensue. Thermal ablation (radiofrequency ablation [RFA], cryoablation) procedures are associated with far greater rates of persistent and recurrent disease (21), and patients deemed likely candidates for ablation are generally the same that we recommend for active surveillance.

PREOPERATIVE PLANNING AND PATIENT PREPARATION

Preoperative assessment begins with a careful history, with a special emphasis on medical comorbidities affecting the cardiovascular and renal function, and a thorough physical examination. Correctable and potentially life-threatening cardiovascular disease should be addressed (i.e., carotid endarterectomy, coronary revascularization) prior to PN. A baseline calculation of estimated glomerular filtration rate (eGFR) should be done using the following web link for the MDRD or CKD-EPI equation (http://www.nephron.com/MDRD_GFR.cgi). Preoperative renal protocol CT imaging must have noncontrast views in search of microscopic fat or pseudo enhancement with volume averaging to exclude benign angiomyolipoma and hemorrhagic cyst, respectively, which would warrant nonoperative management (22). A contrast-enhanced study (MRI, CT, or renal perfusion/excretion nuclear scan) is required to document bilateral renal function. Renal ultrasound with Doppler imaging is an effective way to assess the lesion for vascular flow (23), can fully characterize cystic lesions, and serves as a template for intraoperative ultrasound in order to locate small, endophytic, impalpable subcortical renal tumors (18). In general, preoperative renal tumor biopsy is considered only when this information could dramatically change management if, for example, an infiltrative mass is identified and a renal lymphoma is suspected.

We conduct in-depth discussions describing the anticipated degree of surgical difficulty in completing an anticipated PN, the renal functional result, and a full description of potential complications including bleeding, infection, urinary fistula, the need for a prolonged perinephric drainage, and conversion to RN, if for technical reasons, a PN cannot be executed. A preoperative nomogram can reassure patients with small renal masses that a favorable long-term prognosis is achievable with an effective resection (24). A nephrometry scoring system (R.E.N.A.L.) can categorize the degree of surgical difficulty for a planned PN (25). The likelihood of a subsequent ipsilateral (<5%) or contralateral (<5%) tumor recurrence in a patient's lifetime and the need for lifetime kidney imaging is also discussed.

The anticipated length of the hospital stay and postoperative recovery are described. The importance of walking on the first postoperative day (14 laps around the floor is a mile) to prevent deep venous thrombosis and deep breathing with incentive spirometry to prevent atelectasis and pneumonia is stressed. We rapidly advance patients to a regular diet with conversion to oral pain medication and continued vigorous walking by the second day. The vast majority of patients are discharged on the second postoperative day (10). This regimen of vigorous walking continues at home with a switch to over-the-counter pain medications as soon as possible. We encourage three protein-rich meals per day to maximize healing and continued walking at least 30 minutes twice per day with avoidance of heavy lifting for 3 months.

SURGICAL TECHNIQUE

Supra-11th Rib Mini-flank Surgical Incision

The traditional 11th rib flank incision provided wide exposure, but patients complained of significant postoperative pain, prolonged recovery, and for up to 50%, an uncomfortable and unsightly flank bulge usually caused by denervated muscle often with associated paresthesia and neuralgic pain (7). For the surgeon, rib resection and closure of this large incision also added significant operating time. We developed the "mini-flank" supra-11th rib incision as an effective alternative to standard flank incision or laparoscopic PN (8,9).

The patient is placed in the standard flank position (Fig. 2.1). An 8- to 10-cm extraperitoneal incision is made between the bed of the 10th and 11th ribs (Fig. 2.2). Intercostal ligaments are sharply divided, allowing for further separation of the ribs and rapid exposure to the retroperitoneum without rib resection (Fig. 2.3). The latissimus dorsi, external oblique, and internal oblique muscles are transected, and the transversus abdominis is divided in the direction of its fibers while preserving the intercostal neurovascular bundle. Using blunt dissection, the peritoneal cavity is mobilized medially, the perinephric soft tissues laterally, and the diaphragmatic fibers and pleural superiorly. A small incision in the plane between the soft tissues overlying the psoas muscle (Fig. 2.4A) and Gerota fascia is then bluntly developed, creating a flap of peritoneum (Fig. 2.4B) that is retracted medially and exposes the kidney, ureter, and ipsilateral great vessel (vena cava on the right, aorta on the left). The Bookwalter retractor (Codman and Shurtleff, Inc, Raynham, Massachusetts) is placed using the bladder blade to retract the 10th rib and peritoneal flap superiorly and medially which allows the kidney and perinephric soft tissues to move caudally into the wound. The short right-angle blade retracts the 11th rib laterally. Following blunt dissection of the intestinal contents, deeper malleable blades are placed to expose the great vessels by retracting intestines medially (Fig. 2.5). The ureter is isolated with a yellow vessel loop (Fig. 2.6A), and careful division of lymphatic channels and soft tissues allow isolation of the renal artery and vein with red and blue vessel loops, respectively (Fig. 2.6B). For tumors located in a polar position, once the renal hilar vessels are isolated, it is not necessary to mobilize the opposite pole from the surrounding soft tissues (and adrenal for upper pole). We do not perform mass renal pedicle clamping with vascular clamps during cold ischemia. On the left side, the gonadal and adrenal veins are usually ligated and divided to liberate the tethered renal vein to allow enhanced upward lifting of the kidney and improved access to the renal artery. The upward mobilization of the kidney decreases venous bleeding later during the tumor resection and facilitates identification and repair of rents in renal sinus veins (Fig. 2.7). The upper pole of the kidney is separated from the adrenal using blunt dissection, and perforating vessels are ligated and divided with the LigaSure (Covidien, Mansfield, Massachusetts).

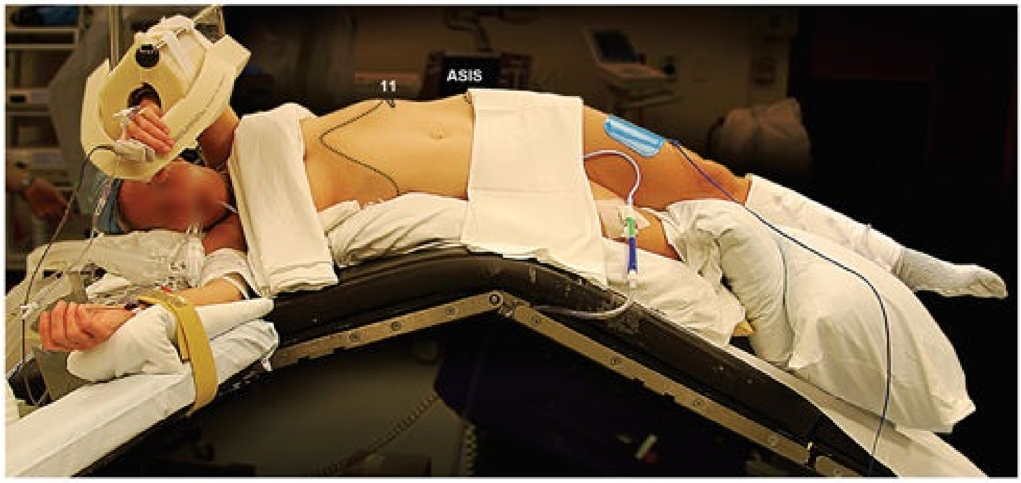

FIGURE 2.1 Patient positioning. The patient is carefully positioned in standard flank position, using approximately 50 to 60 degrees of flank elevation. The patient should be centered on the operating table with the upper brim of the iliac crest below the table break to avoid direct gluteal pressure. An axillary roll is placed. A beanbag is used to hold the patient in position. After rolling to the flank position, the legs are flexed and separated by two pillows, avoiding adduction strain on the upside leg. The leg in contact with the table is flexed to a greater degree with additional padding placed at the hip, knee, and ankle pressure zones. The downside arm is cushioned on an armboard with the elbow flexed. The upside arm is suspended in a foam cradle in neutral position. The patient is secured to the table at the hip with 2-inch fabric tape. Padding is used on the skin such that the adhesive surface of the tape does not come in contact with the skin. A padded safety strap is used to further secure the lower extremities. ASIS, anterior superior iliac spine.

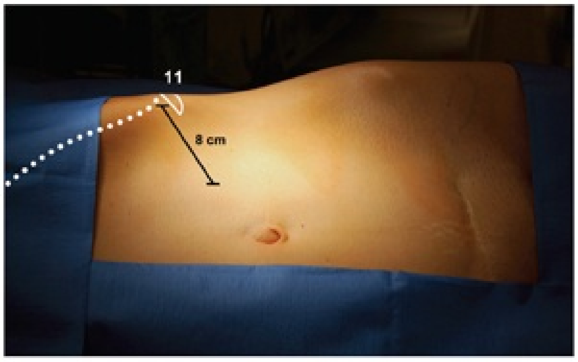

FIGURE 2.2 Mini-flank incision. An 8- to 10-cm extraperitoneal incision is made between the bed of the 10th and 11th ribs. *White broken line*, lower boundaries of the thoracic cage.

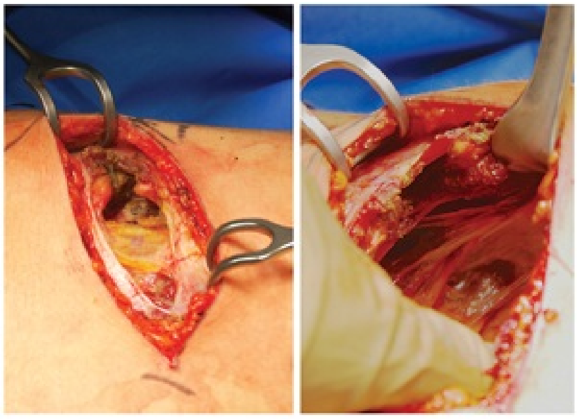

FIGURE 2.3 Intercostal ligaments are cut, allowing more space between ribs and easy access to retroperitoneum. The latissimus dorsi, external oblique, and internal oblique muscles are transected, and the transversus abdominus is divided in the direction of its fibers.

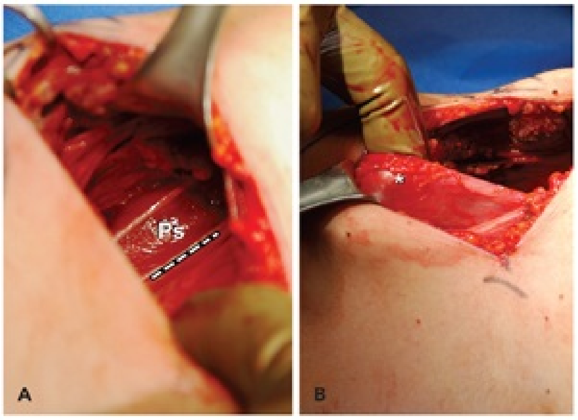

FIGURE 2.4 **A:** A small incision is made in the soft tissues posterior to Gerota fascia which overly the psoas muscle (*Ps*). **B:** Gerota fascia is then bluntly developed and gathered with the peritoneum to create a flap of tissue (*asterisk*) that is retracted medially for exposure.

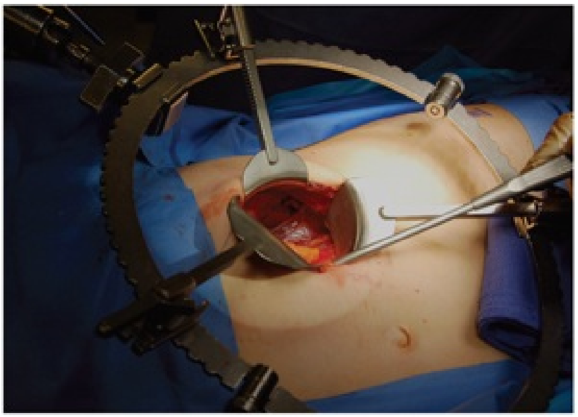

FIGURE 2.5 The Bookwalter retractor is deployed to assist in exposure. Superior and medial retraction of the 10th rib and peritoneal flap is provided by the bladder blade. The short right-angle blade provides lateral retraction of the 11th rib. Right-angle or malleable blades provide inferior and medial retraction.

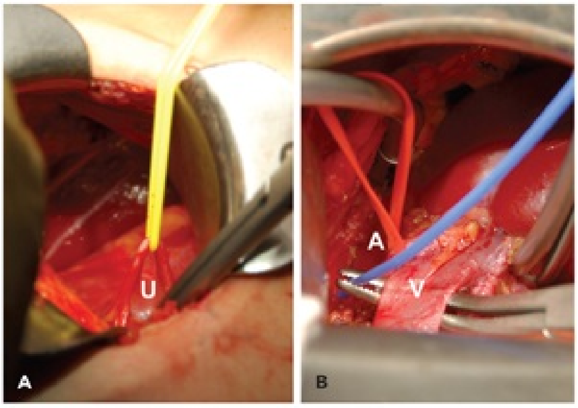

FIGURE 2.6 **A:** The ureter (*U*) is isolated with a yellow vessel loop. **B:** The renal artery (*A*) and renal vein (*V*) are identified and isolated.

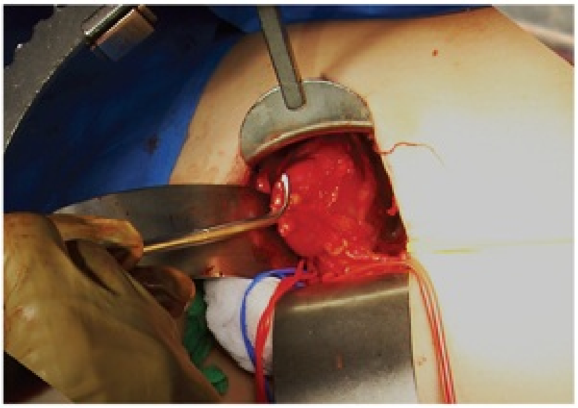

FIGURE 2.7 Upward mobilization of the kidney facilitates identification and control of the renal hilum and decreases venous bleeding during tumor resection.

Tactics for Tumor Resection during Partial Nephrectomy

Following isolation of the renal hilar vessels, careful visual and intraoperative ultrasound (Fig. 2.8) inspection of the renal surface is performed in order to confirm the location and depth of the tumor and identify any satellite lesions, or evidence of branch renal vein or collecting system tumor invasion (18). The surgeon needs to plan a resection strategy based on the location of the tumor, its depth within the kidney, and the presence of segmental arteries or arterial branches that may feed the tumor directly. If the tumor has a polar location with a segmental artery feeding that region, a bulldog clamp can be applied to the feeding artery and, if ischemia covers the tumor bearing area of the kidney, resection can proceed with this form of “regional ischemia,” whereas the rest of the kidney is normally perfused. Similarly, for a tumor that is polar in location, exophytic, and with no renal sinus extension, a Satinsky clamp can be applied to the renal cortex beneath the tumor while resection and cortical hemostasis is obtained without hilar clamping in another form of regional ischemia (Fig. 2.9). For tumors substantially involving either renal pole with sinus fat invasion, a more substantial polar PN is performed. In this setting, arteries, veins, and collecting system elements of the renal sinus will be sizeable with special care to ligate them separately and avoid large, deep bites within the renal sinus which can inadvertently fuse arteries to veins and lead to iatrogenic arteriovenous fistula and delayed bleeding events.

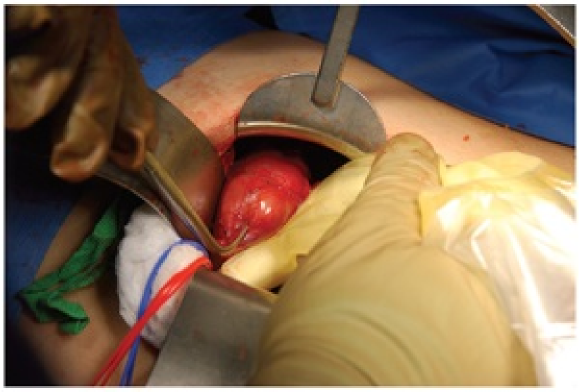

FIGURE 2.8 Intraoperative ultrasound is used to localize the tumor, assess tumor extent, and identify satellite lesions.

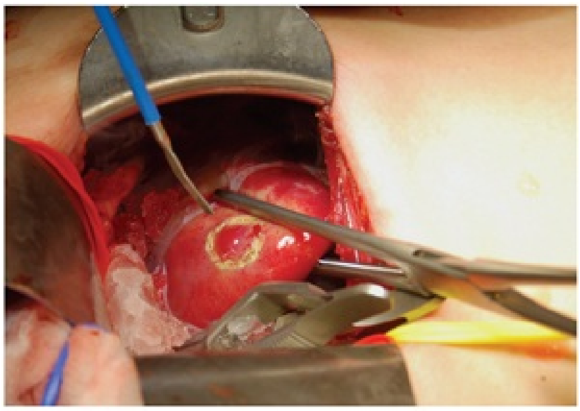

FIGURE 2.9 Regional ischemia provided using straight Satinsky clamp.

For patients with large, endophytic, or perihilar tumors, renal artery occlusion with a bulldog clamp is required to limit blood loss during the resection and to improve visibility. Renoprotective measures, including mannitol infusion (12.5 g per 200 mL of normal saline given 30 minutes prior to clamping) and ice slush, are routinely used. It is unnecessary to place the kidney in a plastic bag prior to applying the ice slush because the small surgical mini-flank incision does not cause the patient significant hypothermia. We always apply renoprotective ice slush hypothermia (Fig. 2.10) if renal artery occlusion is required and see no rationale in open PN for using warm ischemia alone as advocated by some, even if the PN can be rapidly completed.

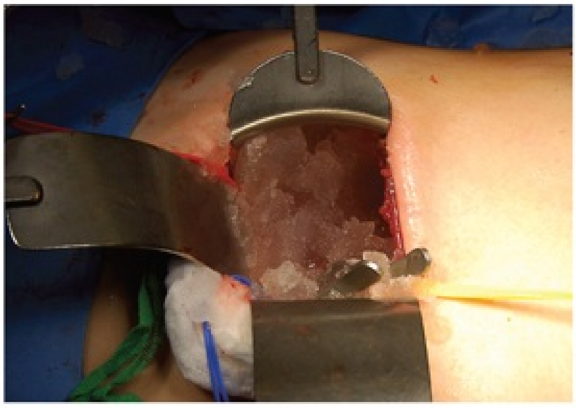

FIGURE 2.10 Iced saline slush hypothermia. Pictured are two bulldog clamps used to clamp the main renal artery and an accessory renal artery.

Following renal hilar clamping, the renal cortex is scored with a 1-cm margin using the electrocautery, and scissor dissection (Fig. 2.11) is used within the renal parenchymal plane (pink kidney tissue) with care not to get too close to the renal tumor’s pseudo capsule (yellowish/golden tissue for conventional clear cell, brownish for oncocytoma, grayish for chromophobe tumors, yellowish/tan for papillary tumors). If dissection is too close to the tumor, readjustment to a deeper plane of dissection is made. A Penfield dissector held by the first assistant gently retracts away the tumor from the operating surgeon and allows the surgeon to avoid the tumor pseudo capsule. We do not “enucleate” the tumor within its pseudo capsule. As the PN proceeds, 3-0 and 4-0 absorbable sutures are used to separately close any open small veins, arteries, and breaches in the collecting system that are encountered (Fig. 2.12). A search for venous bleeding can be accomplished by simply dropping the kidney into the wound (closer to the central venous pressure) and then raising it again. The surgical specimen is inspected to be certain the resection is complete with a rim of surrounding renal and soft tissue and no fractures in the resection margin. The deep tumor surgical margin is marked with a silk suture to orient the specimen which is then sent for a frozen section.

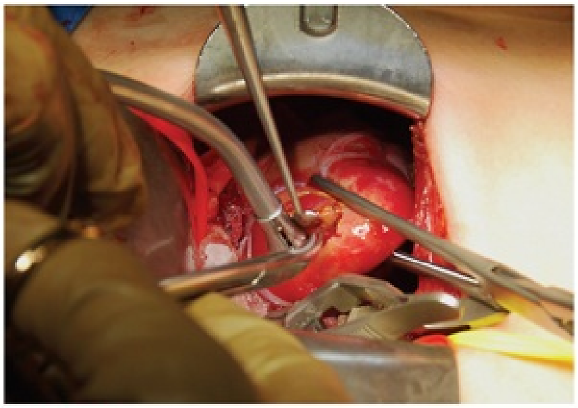

FIGURE 2.11 Sharp scissor and Penfield nerve dissector dissection of the tumor, keeping the plane of surgical dissection within the normal kidney tissue.

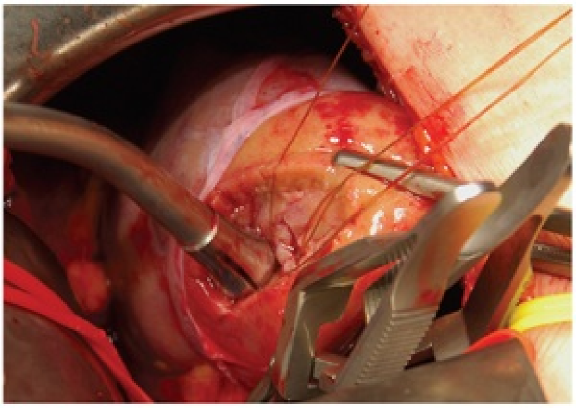

FIGURE 2.12 Direct collecting system repair with 3-0 and 4-0 absorbable sutures (chromic pictured here).

Endophytic and renal sinus based tumors are especially challenging to locate and require careful correlation with preoperative CT and intraoperative ultrasound. Renal sinus tumors can emanate from the renal cortex facing the renal sinus and be attached by a small area of the cortex and otherwise float freely within the sinus without invasion of vascular or collecting system elements. The renal sinus can be accessed through a horizontal cortical incision in the avascular plane (Brödel line) using anatrophic techniques developed in the past for intact removal of staghorn calculi (Fig. 2.13). The tumor is identified on its lateral border and circumferentially dissected with a rim of surrounding cortex. Penfield or Cobb dissectors are used to gently lift the tumor out of the sinus with the final dissection of the actual renal cortical attachment performed sharply. This deep renal cortical attachment is marked with a silk suture as the deep margin to orient the specimen for the pathologist. Surprisingly, little collecting system reconstruction and vascular closure is required in many renal sinus tumor resections.

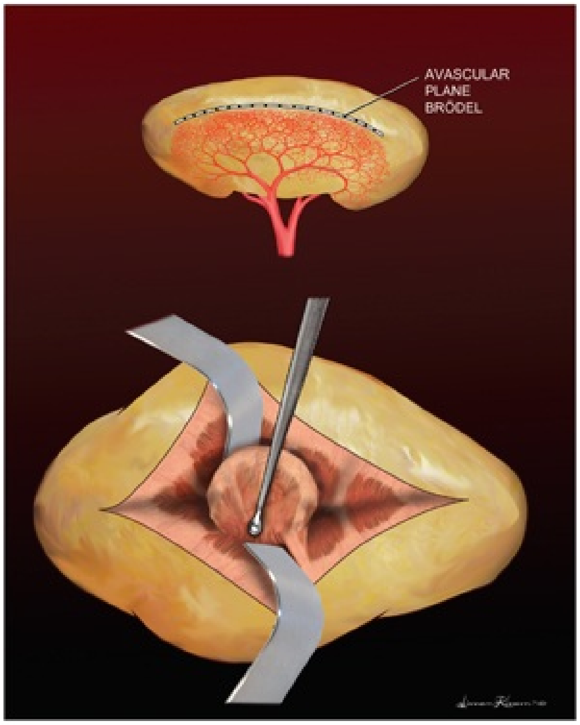

FIGURE 2.13 Endophytic and renal sinus based tumors can be accessed through a horizontal cortical incision in the avascular plane (Brödel line) using anatrophic techniques.

Reconstruction

Following tumor resection, reconstruction of the surgical bed, a combination of hemostasis and repair of any rents in the collecting system, is performed. Using 2.5× optical loupes, fine forceps are used to gently probe the bed for any collecting system rents which, if found, are closed with either interrupted or running 3-0 absorbable sutures. Care is taken to carefully locate and ligate sometimes minute distal arterial branches which can bleed profusely once the main arterial clamp is released. During reconstruction within the sinus, care is taken to include renal papilla with a corresponding calyx and not occlude the stem of a calyx during suture repair, events which could lead to a protracted urinary leak and/or calyceal diverticulum. The cut renal cortex is coagulated using the argon beam coagulator (ABC) (Fig. 2.14A).

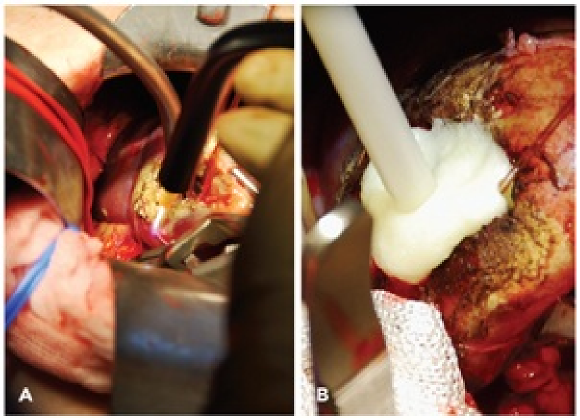

FIGURE 2.14 The ABC is used for hemostasis on the renal cortical surface (**A**), and FloSeal, Surgicel, and perinephric fat are used in the renal cortical resection cavity (**B**).

The resection cavity is then filled with the hemostatic agents FloSeal (Baxter, Deerfield, Illinois) and Surgicel (Johnson and Johnson, New Brunswick, New Jersey) along with any available perinephric fat (Fig. 2.14B). The renal capsule is reapproximated using 0-chromic blunt-tipped liver sutures pledgeted with Surgicel to prevent tearing of the renal cortical capsule and further bleeding (Fig. 2.15). The renal artery is unclamped, and gentle pressure over resection bed is applied for 3 to 5 minutes. If the collecting system was entered, a closed suction Jackson-Pratt drain (Allegiance Healthcare, McGaw Park, Illinois) is placed through a separate stab wound in the retroperitoneal space posterior to the kidney. For exophytic tumors excised completely without entry into collecting system, the drain can be safely omitted (26). If venous oozing from the resection bed persists, another 5-minute period of gentle compression is applied. However, if brisk red arterial bleeding is observed, careful inspection of the bed by cutting one or more liver sutures and ligation of any arterial bleeders is performed. Reclamping of the renal artery is avoided to prevent renal reperfusion injury. The surgical incision is closed in two layers using no. 1 polydioxanone (PDS) for the fascia and 4-0 subcuticular suture for the skin (Fig. 2.16).

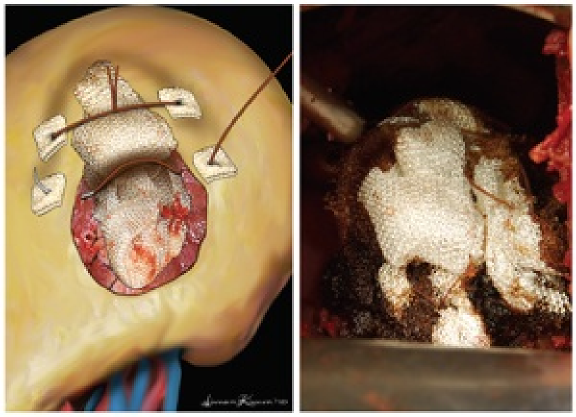

FIGURE 2.15 The renal capsule is reapproximated using 0-chromic blunt-tipped liver sutures pledgeted with Surgicel.

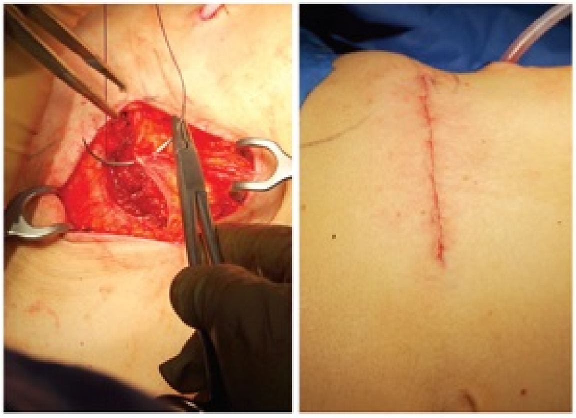

FIGURE 2.16 Closure of surgical incision in two layers using no. 1 PDS, and reapproximation of the skin incision using 4-0 absorbable sutures in a subcuticular fashion.

COMPLEX APPLICATIONS OF PARTIAL NEPHRECTOMY

As our experience with PN has increased, more challenging referrals for PN are being made for tumors which in previous years would have been managed by RN. For patients with sporadic and hereditary bilateral tumors, tumor histologic concordance between the two kidneys is 70% (27–29). We approach the kidney with the largest tumor burden first because it carries the greater oncologic threat (30). The notion of performing the smaller PN first in order to “support” the larger contralateral tumor bearing kidney is no longer applicable because both can now usually be approached by PN. If the pathology of the larger tumor is indolent with limited or no metastatic potential, such as renal oncocytosis or multifocal chromophobe renal cancer, a strong case for nonoperative management with careful observation alone for the contralateral renal tumor can be made (31).

For patients with multifocal tumors, many of which are minute in size, careful visual inspection and intraoperative ultrasound to examine the entire kidney is required. We initially resect as many of the minute tumors as possible using fine scissors or a no. 15 scalpel blade with hemostasis obtained using the ABC. Larger multifocal tumors may require formal PN using cold ischemia. During the resection of centrally located hilar and perihilar tumors abutting proximal major renal arteries and veins, especially in patients with essential indications, a complete resection, even if the surgical margin is close, should be attempted because a microscopically positive surgical margin does not necessarily translate into a local tumor recurrence or worse cancer specific survival (32). For patients with a renal tumor in a solitary kidney, PN can achieve the dual goals of local tumor control and preservation of renal function. When prolonged renal artery ischemia and postoperative acute tubular necrosis (ATN) is anticipated, a preoperative renal medicine consult and placement of a tunneled subclavian dialysis catheter is prudent (33–35) in case postoperative hemodialysis is required before the kidney begins to function again.

During PN, an intrarenal muscular branched vein tumor thrombus, often seen on intraoperative ultrasound, may be encountered. This finding is associated with a worse prognosis than previously appreciated (36), yet PN can still be done using basic vascular surgical principles of proximal and distal vascular control and milking the thrombus back from the vein before dividing it. Similarly, with extension of a renal tumor into the collecting system (37), reconstructive urology principles, up to and including a pyeloplasty are used following the complete excision. Again, care must be taken during the reconstruction not to exclude a papilla from the renal calyceal system which can lead to a prolonged urinary fistula in the absence of retrograde pyelogram evidence of urinary extravasation. Most such leaks close spontaneously but may take weeks or months to do so. We generally do not place indwelling ureteral stents after collecting system repairs because postoperative urinary fistula can be accentuated by reflux of urine from the contralateral kidney. In the rare and difficult circumstance of resection of a tumor involving the majority of a low-capacity intrarenal pelvis where pyeloplasty is no longer an option, closure of the proximal renal pelvis with ureteral calycostomy can achieve proper drainage from the kidney. In this case, we do place a double-J ureteral stent and a closed suction drain.

“Redo” PN can be difficult due to scar tissue involving the renal hilum and is associated with greater operative time, blood loss, and more complications. Meticulous dissection around the renal hilum can lead to a successful repeat PN in the vast majority of cases (38). Treatment failures following thermal ablation procedures are now being referred for salvage PN. If the residual lesions are small and the patient is elderly, frail, or comorbidly ill, we recommend active surveillance which likely would have been our preference over thermal ablation initially. If the patient is young and otherwise well, PN is attempted. Patients are forewarned that PN may be unsuccessful due to extensive fibrosis and scarring with and conversion to RN is a real possibility (39,40).

Medical oncologists may refer patients with metastatic renal cancer whose primary tumor is amenable to a cytoreductive PN. For patients with compromised renal function, PN makes sense; however, if the patient has sufficient renal functional reserve, a strong case can be made for a cytoreductive RN to avoid potential postoperative wound complications associated with the targeted agents that could delay the systemic chemotherapy. Long-term concerns for renal functional decline and potential late cardiovascular morbidity may not be as relevant in this patient population with a generally poor overall prognosis (41–43).

Results

Initial reports in the 1990s of PN for tumors of 4 cm or less indicated equivalent oncologic control to RN (4,44,45) with later reports from the United States and abroad confirming the oncologic equivalency (11–13,46). Expansion of PN to tumors of 4 to 7 cm and later to carefully selected larger size (>7 cm) and higher stage (T2-T3a) did not appear to compromise oncologic efficacy when compared to RN (16,17). In addition, evidence was mounting that when PN was compared to RN for the management of small renal masses, RN was associated with elevated postoperative serum creatinine (47,48) and the development of or worsening of preexisting CKD, which is prevalent in the United States and associated with cardiovascular events and worse overall survival (6). Despite the accumulating clinical evidence supporting the use of PN for small renal masses by guidelines committees (49,50), RN remains overused in the United States and abroad, particularly in elderly patients and women (51–53).

The mini-flank incision is well tolerated by patients and, when coupled with a rapid recovery clinical pathway, is associated with a short hospital stay. In our initial report of 167 consecutive patients undergoing a mini-flank PN, excellent and rapid exposure of the kidney was achieved and only 3.6% of patients reported a flank bulge after 18 months of follow-up with one patient requiring incisional hernia repair (8). In a follow-up report of 280 additional cases, length of stay was 4 days and a flank bulge was reported in less than 2% (9). Muscle atony/bulge at the incision site without hernia is disconcerting for the patient and can be ameliorated or improved completely by exercises that twist the upper torso and core muscles (using an exercise bar, broom, or golf club). For the rare flank hernia, repair with synthetic mesh is more effective than primary closure which is likely to lead to recurrent hernia. With the advent of clinical postoperative pathways emphasizing early ambulation, progression to regular diet, and early switch to oral pain medications, length of stay for PN has been further reduced to 2.6 days (10).

Complications of Open Partial Nephrectomy

Complications related to PN generally fall in the three major categories of urinary fistula, bleeding, and infection. With more complex PN being performed, more complications will be encountered. If PN is performed without entry into the collecting system, urinary fistula is unlikely and the perinephric drain can be omitted and thereby eliminate drain-related patient discomfort as well as a portal for nosocomial infection (26). Factors associated with persistent urinary fistula beyond the immediate and expected postoperative period include tumor in a solitary kidney, prolonged operating time, greater blood loss, endophytic tumor, and collecting system repair. Approximately 4% of patients will have a urinary leak of more than 2 weeks, and investigations such as CT urography and retrograde pyelography can reveal anatomic findings that are actionable. For example, a perinephric drain may heal directly into the kidney and become a virtual nephrostomy tube. Simply backing out the drain can lead to rapid resolution of the fistula. Occasionally, kinks in the proximal ureter from mobilization can lead to preferential leakage of urine from the surgical bed. Placement of a stent can straighten out the ureter and lead to rapid resolution of the fistula. A disconcerting finding in a patient with urinary fistula that is not declining is an intact renal pelvis and calyceal system as seen by retrograde pyelogram in the absence of any contrast extravasation. This implies either an obstructed intrarenal calyx or a renal papilla that is producing urine but without a corresponding calyx to collect the urine. In the former case, a combined percutaneous antegrade and endoscopic retrograde approach is often required to reestablish continuity of the obstructed calyx and the renal pelvis. In the latter case, over an extended time (weeks to months), the renal papilla will stop producing urine and the leakage will end. We have no experience with attempting to destroy this undrained papilla with RFA or cryoablation. We stress excellent nutrition, exercise, and rest in the postoperative period as means to promote wound healing following PN. On rare occasions in patients who apparently have healed, passage of surgical debris or a small stone can cause ureteral obstruction and a delayed leak through the newly healed surgical bed which can present with pain and flank fullness necessitating placement of a percutaneous drain.

Pseudoaneurysm or iatrogenic arterial venous fistula forms when surgical repair of vascular rents fuses arteries and veins with direct communication developing between the two. On rare occasions, a palpable thrill can be noticed over the resection site at the end of a PN. In this case, immediate reexploration of the surgical bed with ligation of the communicating vessels or completion RN is performed. These can present with delayed postoperative bleeding, perinephric hematoma with pain, ureteral colic, gross hematuria, hypotension, flank mass, or flank discoloration from dissecting blood. Following appropriate resuscitation, CT renal protocol is performed which will reveal arterial contrast pooling with or without perinephric hematoma, a finding that should initiate an urgent request for selective renal artery angiogram and coil embolization. The interventional radiologist should make every effort to occlude tertiary and quaternary branches of the renal artery as close to the pseudoaneurysmal pocket as possible in order to limit collateral damage to viable, healthy renal tissue. Memorial Sloan Kettering Cancer Center (MSKCC) reported 15 pseudoaneurysms (1%) during a 7-year period including 7 of 1,160 (0.6%) in open PN. Fourteen of 15 patients were successfully treated with embolization, but 1 patient with a coagulopathy required a completion RN (54).

Follow-up after Partial Nephrectomy

In an attempt to standardize the follow-up after nephrectomy, the American Urologic Association recently published guidelines based on tumor stage. All patients should undergo interval history and physical examination and laboratory testing including blood urea nitrogen (BUN)/creatinine, urinalysis, and eGFR. Low-risk patients (pT1, N0, Nx) should undergo a baseline abdominal scan (CT or MRI) within 3 to 12 months following surgery. If the initial scan is negative, abdominal imaging (US, CT, or MRI) may be performed yearly for 3 years, based on the individual risk for recurrence. In addition, low-risk patients are recommended to undergo yearly chest X-ray (CXR) to assess for pulmonary metastases for 3 years and, if clinically, indicated beyond that period. Moderate-to-high–risk patients (pT2-4N0 or any N+ stage) should undergo baseline chest and abdominal scans (CT or MRI) within 3 to 6 months following surgery, with continued imaging every 6 months for 3 years at least and annually thereafter to year 5. Imaging beyond 5 years may be performed at the discretion of the clinician (55). At MSKCC, after 2 years without evidence of disease recurrence, we refer patients to our “survivorship” clinic where long-term renal cancer follow-up, general medical care, and oncologic screening is provided. As much as possible, renal ultrasound and CXR are used in follow-up unless specific patient signs or symptoms need to be directly addressed by specific imaging studies.

CONCLUSIONS

PN is an essential operation for the management of small renal masses increasingly detected by cross-sectional imaging usually obtained for the evaluation of nonspecific abdominal or musculoskeletal complaints. PN provides equivalent oncologic control for the T1 tumor as does RN while at the same time preventing or delaying CKD and its potential for late cardiovascular morbidity and mortality. This kidney functional preserving effect is amplified by the fact that approximately 45% of patients will have a benign or indolent tumor resected with little or no metastatic potential. A mini-flank supra-11th rib approach is a highly effective operation that should be part of every renal surgeon's arsenal. This approach provides rapid exposure to the kidney, is useful for both straightforward and complex operations, is cost-effective, and is now associated with a median surgical length of stay of 2 days and a marked reduction in flank bulge. Increasingly, challenging PN is being performed, and despite concerns for postoperative complications, the dual goals of oncologic control and preservation of renal function are achieved. Potential complications of postoperative bleeding, infection, and urinary fistula can occur, but most are managed with conservative measures that ultimately preserve the kidney.

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CHAPTER 3 RADICAL NEPHRECTOMY

CHAD R. RITCH, SAM S. CHANG, AND MICHAEL S. COOKSON

Renal cell carcinoma (RCC) is the most common malignancy of the kidney and accounts for about 5% of all adult neoplasms in men and 3% in women. The estimated number of new cases of RCC in the United States in 2012 was 65,150 with a projected 13,680 deaths, and this incidence is expected to continue to increase as a result of the expanded use of radiographic imaging coupled with the aging population (1).

There has been an increase in incidence of RCC and a concomitant decrease in renal mass size and stage at presentation, likely related to the increased use of imaging. This shift in epidemiology has encouraged the American Urological Association (AUA) to develop guidelines specifically addressing the management of the clinical stage I renal mass (2). As such, several treatment options exist for select patients with incidentally discovered renal masses. However, radical nephrectomy remains the mainstay for curative treatment in the majority of patients. In fact, a recent randomized controlled trial by the European Organization for Research and Treatment of Cancer (EORTC 30904) has brought into question the survival benefit of partial nephrectomy for tumors <5 cm as compared to radical nephrectomy (3). Although these findings need to be corroborated, radical nephrectomy remains a standard treatment for most renal tumors to which other options should be compared.

The role of open radical nephrectomy in the management of RCC has changed somewhat over the last decade. Pure laparoscopic, hand-assisted laparoscopic, and robotic radical nephrectomy have emerged as less invasive alternatives to open surgery in the management of low- to moderate-volume (8 to 10 cm or smaller), localized RCCs without local invasion, renal vein involvement, or lymphadenopathy.

However, this has placed an increased emphasis on the performance of open radical nephrectomy in a higher percentage of patients who have either comorbid illnesses or advanced tumors that preclude a minimally invasive approach. Furthermore, the beneficial impact of cytoreductive nephrectomy has increased the clinical situations in which open radical nephrectomy may be performed in the setting of metastatic disease (4).

This chapter focuses on the open surgical approach for radical nephrectomy.

DIAGNOSIS

Typically, RCCs are characterized on computerized tomography (CT) scan by a solid parenchyma mass with a heterogeneous density and enhancement with IV contrast injection (between 15 and 40 Hounsfield units). However, despite modern imaging, some benign tumors and complex cysts may be indistinguishable from cancer and confirmed only after surgical excision or biopsy. As such, the use of percutaneous biopsy has increased in the diagnosis and management of some renal masses and is now included in the AUA guideline (2). Prior concerns of poor accuracy and needle tract seeding have been dismissed by contemporary reports demonstrating low false-negative rates and almost no reports of seeding (2).

Clinical staging in patients suspected of RCC usually includes a contrast-enhanced CT scan of the abdomen, which may include CT angiography as well as three-dimensional reconstructions, and magnetic resonance imaging (MRI) is used on occasion, depending on the clinical scenario.

INDICATIONS FOR SURGERY

The indication for radical nephrectomy is a clinically localized solid renal mass in a patient with a normal contralateral kidney. Patients with solitary kidneys, renal insufficiency, or bilateral renal masses should be considered candidates for nephron-sparing surgery. Partial nephrectomy is acceptable for T1 lesions in the "elective" setting (2). However, for larger lesions, radical nephrectomy remains the treatment of choice. A thorough preoperative history and physical examination should be performed before the procedure. If significant comorbidities are suspected, preoperative consultation with the appropriate physician is recommended. In an elective radical nephrectomy, the patient should be expected to physically withstand the operation, have a reasonable overall performance status, and have a 5-year life expectancy.

Routine lymphadenectomy remains controversial during radical nephrectomy. In fact, the recommendation against the role of routine lymphadenectomy at the time of radical nephrectomy is supported by data from a prospective, randomized controlled trial (EORTC 30881), which found a low incidence of lymph node metastases and no survival advantage with complete lymph node dissection (5). This study has been criticized for a low number of men at risk for nodal metastases but nevertheless adds support to this argument, and currently, lymphadenectomy is offered to selected high-risk individuals.

Radical nephrectomy in combination with immunotherapy for metastatic RCC (i.e., cytoreductive nephrectomy) has been demonstrated to improve survival among patients with metastatic RCC over immunotherapy alone (4,6). The tyrosine kinase inhibitor (TKI) class of medications has surpassed immunotherapy as the standard systemic therapy for metastatic disease (7). However, the concept of cytoreductive nephrectomy is still applied in the setting of TKI treatment for metastatic RCC. Accordingly, radical nephrectomy is offered to patients with a resectable primary tumor in the setting of metastatic disease as an initial treatment strategy prior to systemic therapy. Radical nephrectomy may also be performed for palliation, such as for patients with intractable pain or life-threatening hemorrhage who fail conservative treatment despite the presence of metastases. The role of radical nephrectomy among patients with a solitary metastatic site is controversial; however, modest 5-year survival rates have been reported in selected patients, with best results reported in patients with solitary pulmonary metastases (8).

Although local extension of primary RCC into the perinephric fat, vena cava, or ipsilateral adrenal gland may portend a worse prognosis, in the absence of metastatic disease, these factors alone should not dissuade the surgeon from attempting a radical nephrectomy. Similarly, regional lymphadenopathy should not exclude a patient from undergoing a radical nephrectomy. In addition, radical nephrectomy has been successfully performed in the setting of direct extension of the tumor into adjacent organs such as the liver, colon, spleen, pancreas, or psoas muscle. However, surgical removal in this setting is technically difficult and is associated with a higher morbidity and a potentially poor prognosis. Therefore, it should be attempted only after careful preparation and in cooperation with appropriate surgical consultants.

ALTERNATIVE THERAPY

Surgery remains the only effective and potentially curative form of therapy for primary RCC. Along this line, the main challenge to radical nephrectomy in the near future appears to be from more conservative surgical approaches, including nephron-sparing surgery and minimally invasive approaches. Retrospective series of elective partial nephrectomy, enucleation, and wedge resection have demonstrated equivalence in terms of cancer control and may afford potential advantages in terms of preserved renal function and quality of life in properly selected patients (9–11). However, results from EORTC 30904 demonstrated that overall survival was higher in patients undergoing radical nephrectomy (3).

Radical nephrectomy is also being performed through laparoscopic approaches, including hand-assisted techniques, which again have shown equivalent cancer control and significant advantages in terms of reduced pain, shorter convalescence, and improvements in quality of life (12).

Open radical nephrectomy continues to play an important role in the management of RCC, and it is essential that any surgeon who employs minimally invasive techniques be well versed in its performance.

SURGICAL TECHNIQUE

There are a variety of factors that influence the choice of incision during radical nephrectomy. These include location of the affected kidney, tumor size and characteristics, body habitus, and physician preference. There are advantages and disadvantages to each incision, and it is important to be familiar with several approaches to the kidney as no one incision is appropriate in all settings. The most commonly used incisions for radical nephrectomy are the flank, thoracoabdominal, and transabdominal (subcostal or chevron) (Fig. 3.1).

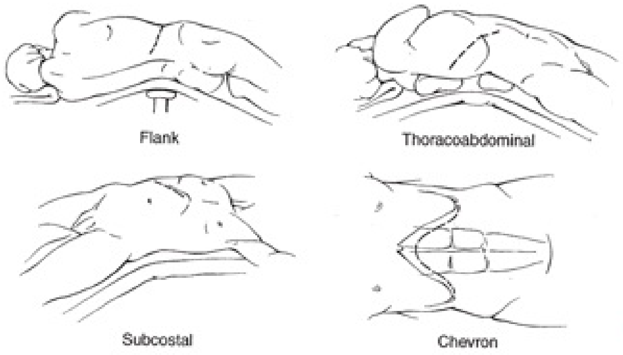

FIGURE 3.1 Types of incisions during radical nephrectomy.

Flank Incision

The flank approach can be advantageous for several reasons. First, it allows direct access to the retroperitoneum and kidney, and the entire procedure can often be performed in an extrapleural and extraperitoneal fashion. In addition, the incision is anatomic in that it follows the track of the intercostal nerves with minimal risk of denervation. However, in large tumors, tumors involving the upper pole, or situations where vena cava access is critical, a flank approach is often suboptimal. Although a flank approach may be performed through a subcostal incision, an 11th- or 12th-rib incision is superior for exposure of the upper pole and ipsilateral adrenal gland during radical nephrectomy.

The patient is positioned in the lateral decubitus position with the upper chest at about a 45-degree angle. An axillary roll is placed under the patient to cushion against pressure on the brachial plexus, and the elbows are padded to prevent ulnar nerve injury. The upper arm is draped across the body and placed on a Mayo stand or padded support. The lower leg is flexed at 90 degrees, and the upper leg is extended over one or two pillows. The kidney rest is raised and the table is flexed to elevate the flank and adjusted to make the flank horizontal to the floor. A beanbag or inflatable mattress may be helpful, and if utilized can be activated to further support the patient. The patient is then padded and secured with wide adhesive tape and safety straps.

An 11th- or 12th-rib incision is made based on several factors, including the kidney position, the cephalad extent of the tumor, and the patient's body habitus. A general rule is to incise over the rib so that, when extended medially, the incision will be over the renal hilum. The incision is then made off of the tip or over the rib from the posterior axillary line to the tip and extended medially as far as necessary, usually stopping short of the lateral border of the rectus abdominis (Fig. 3.2). The latissimus dorsi is divided, and the upper portion of the incision is carried down to the rib or near its tip. The incision is usually created between the ribs in the intercostal space, and additional exposure may be obtained by incising the costovertebral ligament. With larger tumors and depending on patient body habitus, a partial rib resection may be accomplished as shown in Figure 3.3. An Alexander periosteal elevator is used to deflect the periosteum from the bone to avoid injury to the intercostal bundle located under the inferior portion of the rib. A Doyen elevator is then used to strip the periosteum from the entire undersurface of the rib to be resected. Next, a rib cutter is used to divide the proximal segment of the rib. The posterior layer of the periosteum is then incised carefully, and the pleura is protected superiorly.

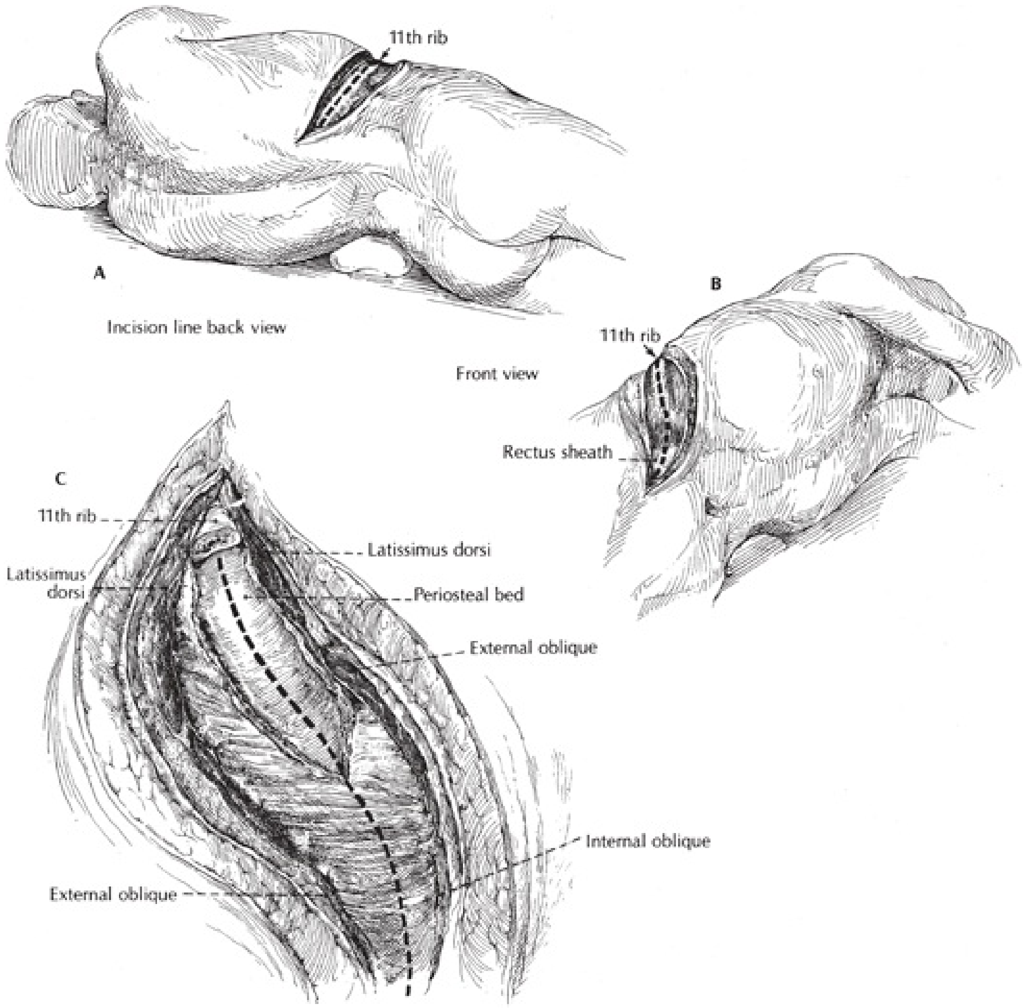

FIGURE 3.2 Technique of 11th-rib resection. **A and B:** The incision is made over the 11th rib. **C:** After division of the latissimus dorsi and external oblique muscles, subperiosteal resection of the rib is performed. *(continued)*

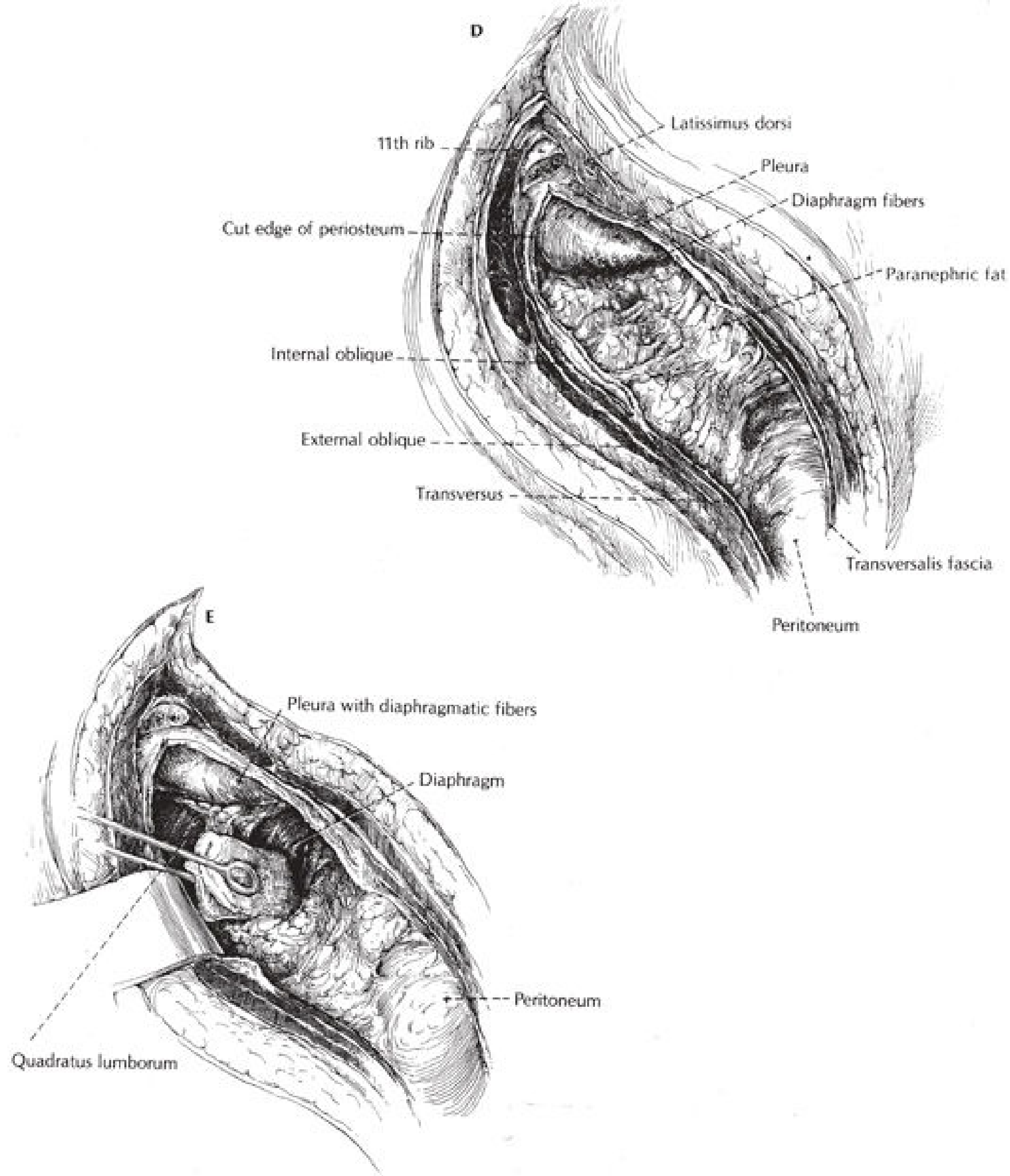

FIGURE 3.2 (*continued*) **D:** The incision is carried through the periosteum posteriorly and the internal oblique and transversus muscles medially, exposing the paranephric space. A tongue of pleura lies in the upper portion of the wound. Diaphragmatic slips that come into view are divided, and the pleura can be retracted upward. **E:** The paranephric fat is dissected bluntly.

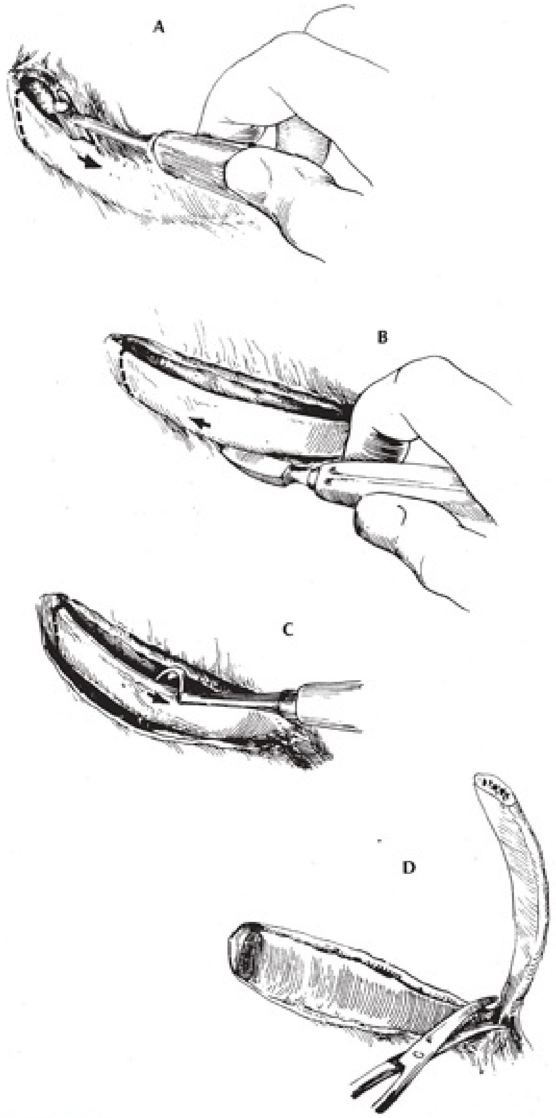

FIGURE 3.3 Rib resection technique. **A:** After exposure of the rib, the intercostal muscles are stripped from the upper and lower rib surfaces with an Alexander–Farabeuf costal periosteotome. **B:** The rib is freed from the periosteum by subperiosteal resection or from the pleura with a periosteum elevator. **C:** A Doyen costal elevator is slipped beneath the rib to free it. The proximal and distal portions of the rib are immobilized with Kocher clamps, and the rib is divided proximal to its angle with a right-angled rib cutter. **D:** The costal cartilage is cut free with scissors. The cut surface of the rib is inspected for spicules, which are removed with a rongeur and covered with bone wax.

Anteriorly, the external and internal oblique muscles are divided and the transversus abdominis muscle is split in the direction of its fibers, taking care not to enter the peritoneum. The peritoneum is swept medially, and the intermediate stratum of the retroperitoneal connective tissue is incised sharply to expose the perinephric space. Approaching this in a posterior fashion with early identification of the psoas muscle helps keep proper orientation. A self-retaining retractor such as a Balfour, Bookwalter, Omnitract, or Finochietto rib spreaders helps maintain exposure. A radical nephrectomy is then performed.

The wound is closed after checking to ensure that no injury to the pleura has occurred (see "Complications"). The table flex is released and the kidney rest is lowered. The posterior layer consisting of the fascia of the transversus abdominis and the internal oblique is closed in a running fashion with no. 1 polydioxanone suture (PDS) or Prolene. The anterior layer of external oblique fascia is closed with a running no. 1 PDS or Prolene. Alternatively, interrupted figure-of-eight sutures of no. 1 Vicryl can be used for both layers. The skin is closed in accordance with the surgeon's preference.

Thoracoabdominal Incision

The thoracoabdominal approach allows for excellent exposure of large tumors as well as upper-pole tumors, in particular on the left. In addition, it affords easy access to the adrenal gland and thoracic cavity. The patient is positioned with the hips flat and with the break of the table located just above the iliac crest. The pelvis can be torqued up to about 30 degrees if necessary. The patient's ipsilateral shoulder is rotated 45 degrees, and the ipsilateral arm is extended over the table and properly supported on a Mayo stand or padded armrest (Fig. 3.4). It is important to properly pad all pressure points, including between the legs and the contralateral shoulder. The kidney rest may be elevated to accentuate the proper extension, and the break in the table is made to optimize the incision. After positioning, the patient is secured with wide adhesive tape and safety straps.

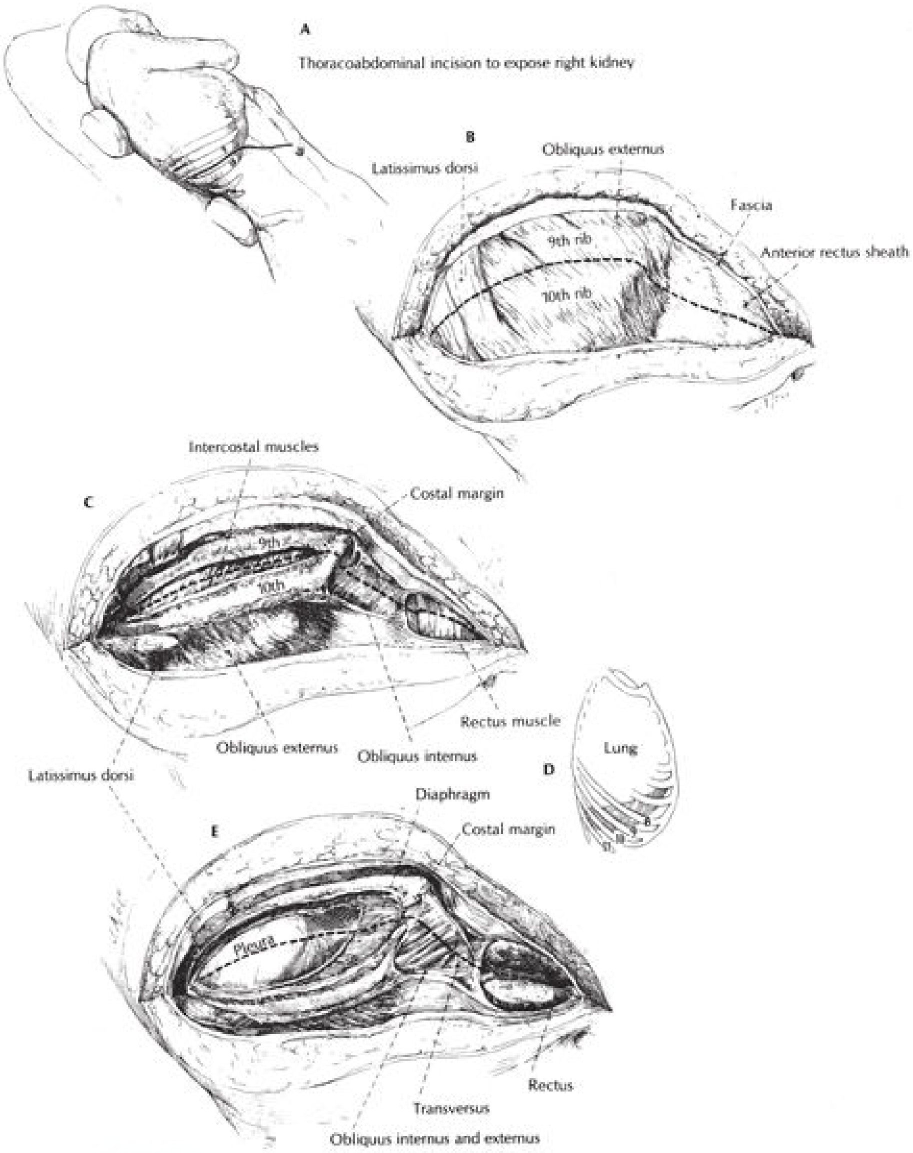

FIGURE 3.4 Thoracoabdominal incision. **A:** The patient is placed in a semirecumbent position using sandbags. If the chest is entered through the ninth intercostal space, the incision extends from the midaxillary line across the costal margin at the intercostal space to the midline or across it just above the umbilicus. **B:** The anterior rectus sheath and the external oblique and latissimus dorsi muscles are divided. **C:** The intercostal muscles parallel the direction of the three abdominal layers and are divided. The costal cartilage and the internal oblique and rectus muscles are incised. If more exposure is desired, the linea alba and opposite rectus can be divided. **D:** The pleural reflection (*shaded areas*) lies progressively closer to the costal margin in the more cephalic intercostal spaces. **E:** The pleura, reflecting as the costophrenic sinus near the costal margin, is exposed beneath the intercostal muscles. The diaphragm can be seen inferior and dorsal to the pleura. The pleura is opened with care to avoid injuring the lung, which comes into view with inspiration. After the lung is packed away gently, the diaphragmatic surface of the pleura is seen. The diaphragm is incised on its thoracic surface, avoiding the phrenic nerve. (*continued*)

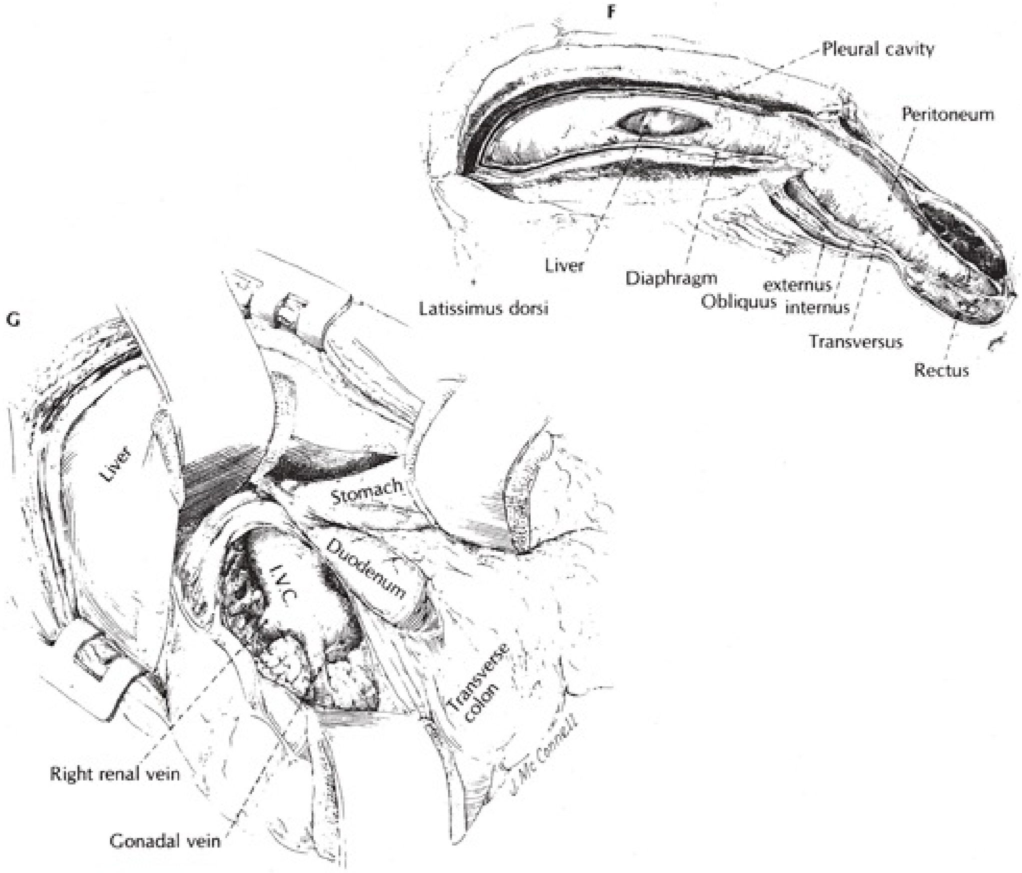

FIGURE 3.4 *(continued)* **F:** The transversus abdominis muscle is divided, exposing the peritoneum with the liver lying beneath it. **G:** The peritoneum is incised, and a rib-spreading retractor (Finochietto) is inserted, enabling upward displacement of the liver (or the spleen on the left) into the thoracic cavity and giving wider access to the posterior peritoneum than in an anterior abdominal incision.

The thoracoabdominal incision is made over the bed of the 8th, 9th, or 10th rib, depending on the surgeon's preference based on patient and tumor characteristics. The incision may be made between the ribs, or a portion of the rib may be removed. The incision is made over the rib beginning at the posterior axillary line. The incision is carried medially across the costal cartilage margin to the midline and then carried down the midline to the umbilicus. Alternatively, the medial portion of the incision may be carried across the midline or combined with a low midline to form a T shape. The latissimus dorsi is divided, and the upper portion of the incision is carried down to the rib. At this point, a rib resection can be performed as previously described (see Fig. 3.3).

The peritoneum may be entered by incising the external and internal obliques, the transversus abdominis, and the ipsilateral rectus abdominis. Next, the costochondral cartilage at the inferior portion of the upper thoracic incision is divided, and the chest is entered along the entire length of the periosteal bed. The pleural space is entered, and care should be taken not to injure the lung. The lung is protected, and the diaphragm is divided in the direction of the muscle fibers, which helps avoid injury to the phrenic nerve. A self-retaining retractor such as a Balfour, Bookwalter, Omnitract, or Finochietto rib spreaders is properly padded and placed to maintain exposure. A radical nephrectomy is then performed.

After completion of the radical nephrectomy, the table flex is removed and the diaphragm is closed with interrupted 2-0 permanent sutures with knots placed on the inferior (peritoneal) side. After a 20Fr to 18Fr chest tube has been inserted through a separate incision and properly positioned, the ribs are reapproximated with 2-0 absorbable sutures. The thoracic portion of the incision is closed with interrupted figure-of-eight 1-0 Vicryl sutures through all layers of the chest wall. The medial portion of the intercostal muscle closure should include at least a small portion of the diaphragm. An intercostal nerve block is administered before closure and may be accomplished by injecting approximately 10 mL of 1.0% lidocaine or 0.5% bupivacaine hydrochloride into the intercostal space of the incision and two interspaces above and below. The costal cartilage can be reapproximated with 0 chromic sutures. This is essential to prevent “clicking” of the ribs, which is oftentimes bothersome to the patient. The posterior rectus fascia, the fascia of the transversus abdominis, and the internal oblique muscles are closed with a running no. 1 PDS. The anterior rectus and the external oblique fascia are closed with either a running or interrupted no. 1 PDS. Skin closure is determined by surgeon preference. The chest tube is secured in place with a 0 silk and taped securely in place.

Transabdominal (Chevron or Anterior Subcostal) Incision

Anterior incisions offer several advantages, including excellent exposure of the renal pedicle and access to the entire intraperitoneal contents and contralateral retroperitoneum. With the patient in the supine position, the operative side is elevated slightly with a flank roll and the patient hyperextended to accentuate the line of incision. An incision is made from near the tip of the 11th or 12th rib on the ipsilateral side two fingerbreadths below the costal margin and extended medially to the xiphoid process. The incision is then gently curved across the midline and as far laterally as necessary for exposure up to near the tip of the contralateral 11th rib.

On occasion, only a portion of the contralateral side will be incised just across the rectus abdominis. The incision is carried down to the anterior rectus fascia, which is then divided (Fig. 3.5). Next, the external and internal oblique fascia and muscles are divided and the fibers of the transversus abdominis split. The rectus muscle and posterior rectus sheath are divided with electrocautery by placing a straight clamp underneath and gently elevating it. The peritoneal cavity is then entered, and the falciform ligament is ligated between two Kelly clamps, divided, and ligated. To facilitate exposure, use of a self-retaining retractor such as a Bookwalter (oval or segmented) or an Omni-Flex is helpful. A radical nephrectomy is then performed.

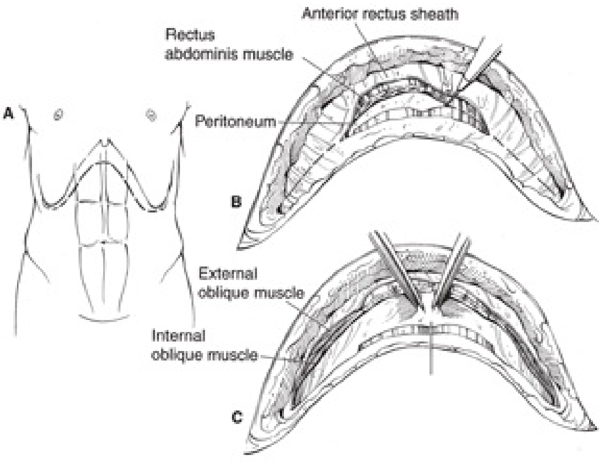

FIGURE 3.5 Transabdominal chevron incision. **A:** With the patient in the supine position and slightly hyperextended, an incision is made two fingerbreadths below the costal margin to just below the xiphoid process and then curved gently down across to the tip of the opposite 11th rib. **B:** The subcutaneous tissue and the anterior rectus sheath are divided bilaterally. A Kelly or an Army-Navy retractor is insinuated under the rectus muscle, and the muscle is divided with electrocautery. **C:** The external oblique and internal oblique muscles are divided, and the transversus abdominis is split. The peritoneal cavity is entered in the midline by tenting up on the peritoneum and incising sharply with Metzenbaum scissors.

Closure of the wound is performed after the table is returned to the horizontal position. The wound is then closed in two layers. The posterior layer consisting of the fascia of the transversus abdominis and the internal oblique laterally along with the posterior rectus fascia medially is closed with two running no. 1 PDS sutures, each starting at the lateral aspect and running medially to the midline. The anterior layer of external oblique and anterior rectus fascia is closed in a similar fashion with no. 1 PDS. On occasion, it is helpful to place a U stitch of no. 1 Prolene at the apex of the chevron incision (at the location of the linea alba) before closure, including the rectus fascia on either side of the midline, securing this suture after the anterior fascia has been approximated. The skin is then closed according to the surgeon’s preference.

Radical Nephrectomy

Irrespective of the choice of incision, certain caveats are universal for the safe and successful completion of a radical nephrectomy. They include a systematic approach with careful mobilization of Gerota fascia and careful vascular control. For a flank approach, the posterior peritoneum lateral to the colon is incised along the length of the descending colon (left side) or ascending colon (right side) and reflected medially. For left-sided exposure, the lienorenal ligament is incised to mobilize the spleen cephalad. On the right side, the hepatic flexure of the colon is mobilized. The ureter is identified and encircled with a vessel loop. The gonadal vein is ligated and divided routinely on the left and when necessary on the right. The plane between the mesentery of the colon and Gerota fascia (often referred to as the gonadal space) is then developed using a combination of sharp and blunt dissection. On the right side, kocherizing the duodenum is essential and exposes the vena cava. Using blunt and/or sharp dissection with electrocautery, the retroperitoneal fat overlying the renal vessels is separated, exposing the renal hilum. It is often helpful to ligate and divide the ureter before attempting to expose the renal hilum to allow for mobilization and upward displacement of the lower pole of the kidney.

The dissection is then carried cephalad along the vena cava (right side) or aorta (left side). On the right side, the right renal vein is identified exiting from the vena cava, isolated, and encircled with a right-angle clamp and a 0 silk suture and tagged. After identification of the renal artery (exposure from the anterior approach may be enhanced by the use of a vein retractor on the renal vein), the artery is dissected free and cleaned for a distance of approximately 2 to 3 cm. With a right-angle clamp, the renal artery is encircled, and 2-0 silk ties are passed (Fig. 3.6). The sutures are then separated and tied, allowing a safe distance for division of the artery, and it is preferable to leave two ties on the aortic side. A right-angle clamp is placed under the artery to be divided and gently elevated, and the artery is cut with either a knife (no. 15 blade) or Metzenbaum scissors. The right renal vein is then ligated with two 0 silk sutures and one additional 2-0 suture ligature on the side of the vena cava. Alternatively, the vessels may be encircled with a vessel loop as opposed to a suture, and the renal artery and vein can then be individually ligated using a stapling device with vascular load.

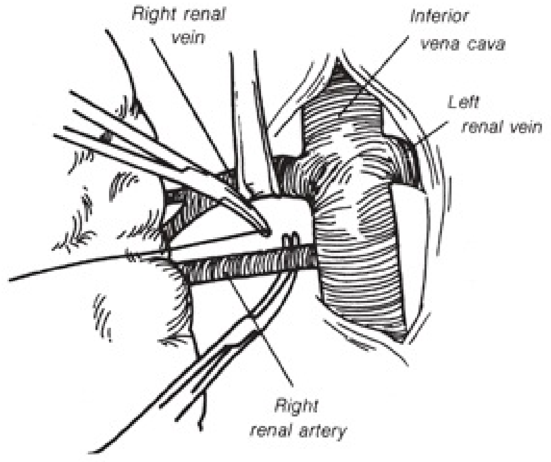

FIGURE 3.6 The right renal artery is identified by palpation beneath the vein. After identification with a right-angle clamp, the artery is cleaned in the same manner as the vein. With a right-angle clamp beneath the artery, a suture is passed on a tonsil clamp to the mouth of the right-angle clamp, and the suture is passed around the artery. (Reprinted with permission from Donohue RE. Radical nephroureterectomy for carcinoma of the renal pelvis and ureter. In: Crawford ED, Borden TA, eds. *Genitourinary Cancer Surgery*. Philadelphia: Lea & Febiger, 1982:101.)

On the left, the renal vein is isolated as it courses over the aorta. The left adrenal and gonadal veins are identified emanating from the left renal vein, and, if present, a posteriorly directed lumbar venous tributary is noted. A right-angle clamp is passed around the renal vein, followed by a 0 silk suture proximal to the tributaries, and tagged. The venous tributaries are then individually ligated and divided with 2-0 or 3-0 silk where necessary, leaving the 0 silk suture on the main renal vein tagged (Fig. 3.7). The left renal artery and vein are then ligated similarly to the technique described previously for the right side. As with the right side, the vessels may alternatively be ligated with a stapling device.

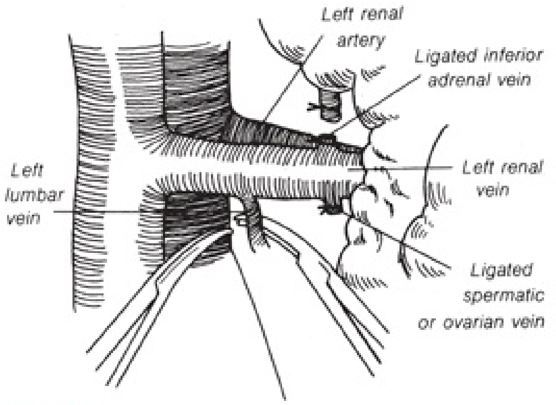
Left renal artery
Ligated inferior adrenal vein
Left lumbar vein
Left renal vein
Ligated spermatic or ovarian vein

FIGURE 3.7 The same technique for ligation is employed on the left side. A suture is passed around the lumbar vein proximally and distally after the vein has been cleaned, and the vein is ligated. Sutures are passed around the main renal vein but are not tied until after the branches have been ligated. The artery is identified above the vein and cleaned, isolated, and ligated, and the proximal end is sutured with a 5-0 cardiovascular silk suture. (Reprinted with permission from Donohue RE. Radical nephroureterectomy for carcinoma of the renal pelvis and ureter. In: Crawford ED, Borden TA, eds. *Genitourinary Cancer Surgery*. Philadelphia: Lea & Febiger, 1982:101.)

Depending on the location of the tumor, prior to control of the renal hilum, Gerota fascia may be initially mobilized posteriorly and superiorly using a combination of sharp and blunt dissection, or this can follow ligation and division of the renal vessels. Small clips placed along the superior and medial border are useful to control any potential bleeding during this portion of the procedure. These should be avoided anywhere near the renal hilum as they may prove problematic if bleeding is encountered. The adrenal hilum is then dissected from caudal to cranial with the aid of either clips or straight clamps and ties. On the right side, the short posteriorly located right adrenal vein should be anticipated as it exits directly from the vena cava. When encountered, the right adrenal vein is isolated, ligated, and divided. The specimen is then delivered and meticulous hemostasis is achieved.

OUTCOMES

Complications

The potential for bleeding during radical nephrectomy necessitates careful patient preparation and preoperative planning to significantly reduce the chance of bleeding. Any medications that interfere with platelet function or clotting should be discontinued. A preoperative hematocrit should be obtained, and a type and screen are in general recommended. In patients with significant anemia or in those in whom significant blood loss is anticipated, a type and cross-match for possible transfusion should be performed. The patient should have either two large-bore peripheral IV lines or a central venous line to allow for rapid infusion of fluids or blood products if necessary.

Bleeding during radical nephrectomy may be from a variety of locations, including the renal hilum, collateral tumor vessels, or adjacent structures. Venous bleeding is usually the most problematic. The first maneuver is to apply direct pressure to the area of bleeding and allow for appropriate resuscitation before additional maneuvers are considered. The point of bleeding is then carefully exposed and controlled by a suture ligature. In the case of vena caval injury, pressure can be applied carefully with sponge sticks, and then an Allis or Satinsky clamp may be carefully placed; a vascular 5-0 or 6-0 Prolene suture is used to oversew the defect. Lumbar veins should be exposed by gentle retraction of the vena cava, appropriately clamped, ligated with vascular silk suture, and divided. Renal artery bleeding may be controlled by direct pressure on the aorta proximally and distally until adequate exposure can be obtained, and the artery is then ligated. Only in certain circumstances will a pedicle clamp or en bloc ligation be necessary.

Adrenal tears may result in significant hemorrhage during radical nephrectomy, in particular on the right side, where the short adrenal vein enters into the vena cava directly posterior. Control of the right adrenal vein should be attempted only after control of the vena cava, adequate exposure, and proper suction. The vein is then ligated with a 2-0 or 3-0 silk tie or vascular Prolene. Venous bleeding from a torn adrenal gland can be oversewn with a running suture or stopped by placement of surgical clips. However, removal of the ipsilateral adrenal may be the most expeditious method of controlling bleeding.

Failure to recognize a rent in the pleura during flank incision will result in a pneumothorax. Filling the flank wound with sterile water or saline and administering a deep inspiratory breath may help recognize small openings in the pleura. Small tears recognized intraoperatively can be managed by closing the pleura with a 3-0 chromic purse-string suture over a 12Fr or 14Fr Robinson catheter. Before it is removed, all air is aspirated from the pleural cavity either by suction or by placing the Robinson catheter under water and administering a deep inspiratory breath. The air is evacuated from the pleural space and the tube is removed while the purse-string suture is simultaneously tied in place. Alternatively, the Robinson catheter can be temporarily left in place with the chromic suture secured and the fascial layers closed around the catheter, which exits from the corner of the wound. Just before skin closure, after all air has been evacuated under water seal as described earlier, the catheter is removed. The latter technique is helpful when the pleura is attenuated or contains multiple small holes that are not easily closed. Alternatively, a 22Fr or 24Fr chest tube may be placed and left to suction and removed postoperatively.

An upright end-expiratory chest X-ray is obtained after all flank incisions to ensure that no significant pneumothorax exists. A small (usually <15%), asymptomatic pneumothorax can be followed conservatively with serial chest X-rays and oxygen therapy. In a symptomatic or large pneumothorax, aspiration of the pleural space using a needle or a central venous catheter (Seldinger technique) introduced just over the rib in the anterior fourth or fifth interspace can be therapeutic. However, if these attempts are not successful, a chest tube should be inserted and placed on suction.

Injuries to the colon during radical nephrectomy are uncommon. In locally advanced tumors with suspected extension into either the colon or mesentery, patients should undergo a preoperative mechanical and antibiotic bowel preparation. Segmental colon resection and primary anastomosis should be possible in most cases. Inadvertent injury to the colon during radical nephrectomy can usually be repaired primarily; however, in situations where there is gross spillage of fecal contents or a devascularized segment, a diverting colostomy should be considered, and a general surgery consultation is advisable. Defects in the mesentery of the colon should be closed to prevent internal herniation of peritoneal contents.

Right radical nephrectomy is also associated with the potential for injury to the duodenum and liver. The duodenum must be carefully mobilized, and care must be taken to properly pad retractors to prevent injury to the bowel and adjacent structures, including the head of the pancreas. The second portion of the duodenum may be injured during a right radical nephrectomy. Duodenal hematomas should only be observed, but rapidly enlarging hematomas will require control of the bleeding, and an intraoperative general surgery consultation should be obtained. Duodenal lacerations should be repaired in multiple layers with interrupted nonabsorbable sutures for the mucosal and serosal layers (1). When possible, an omental wrap may provide additional support, and all patients should be managed with a nasogastric tube during the postoperative period.

Bleeding from superficial liver lacerations may be controlled with Bovie electrocautery or an argon beam electrocoagulator. More significant bleeding may be repaired with absorbable horizontal mattress sutures utilizing a Surgicel or Gelfoam bolster. Deep liver lacerations, which may involve the hepatic ducts, could result in bile leakage and should be drained following repair; an intraoperative general surgical consultation is strongly recommended. Direct invasion of the liver by RCC is rare; however, resection including en bloc removal is possible in selected cases. If a major lobectomy or a partial hepatectomy is to be performed because of either direct extension or major hemorrhage, a general surgeon should be present to assist in its performance.

Splenic injury is one of the most common intraoperative complications during a left nephrectomy, with an incidence as high as 10% in some series. Most superficial lacerations or tears can be managed conservatively without the need for splenectomy. Although minor tears may require only some gentle pressure and the application of a Gelfoam or Surgicel bolster with spray thrombin, closure of a moderate splenic capsular tear is facilitated through the use of nonabsorbable sutures over bolsters of Surgicel. Major hemorrhage secondary to severe splenic lacerations may require splenectomy (13).

The splenic artery and vein are controlled by compressing these structures, which are located in the splenic hilum near the tail of the pancreas. Initially, this can be accomplished manually by compressing the tail of the pancreas between the thumb and forefinger. Once bleeding has been temporarily controlled, the spleen is mobilized by dividing the splenocolic and splenorenal ligaments as well as taking down the peritoneal attachments to the diaphragm. The short gastric vessels are then ligated, and the hilum of the spleen is dissected free from the tail of the pancreas. The splenic artery and vein are ligated and divided. The pancreas should be inspected closely to rule out inadvertent injury. Following splenectomy, patients will have a reduced resistance to *Streptococcus pneumoniae*, *Haemophilus influenzae* type b (Hib), and *Neisseria meningitidis* and should therefore receive pneumococcal and meningococcal vaccines as well as HibTITER postoperatively. Pneumococcal revaccination is required every 6 years, whereas meningococcal and Hib vaccination are not routinely readministered.

RESULTS

Surgical excision remains the only effective and potentially curative therapy for clinically localized RCC. Pathologic staging remains the best prognostic variable in terms of patient survival, and the most commonly used staging system is the 2009 American Joint Committee on Cancer recommendations (TNM) classification (14). The 5-year survival rate for patients with organ-confined tumors treated with radical nephrectomy for T1N0M0 tumors is between 80% and 100%, whereas that for T2N0M0 tumors is 50% to 80% (8). For those patients with T3aN0M0 (tumor invading into the renal vein, perinephric or renal sinus fat), T3bN0M0 (tumor invading into the IVC below the diaphragm), and T3cN0M0 (tumor invading the IVC above the diaphragm or into the wall of the IVC) carcinomas, the 5-year survival rates are 40% to 70%, 30% to 50%, and 20% to 40%, respectively (8). Finally, patients with locally advanced (T4) or node-positive disease (N1-3,M0) have a 5-year survival rate between 0% and 20% (8).

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CHAPTER 4 ■ INTRACAVAL TUMORS

WILLIAM C. FAUST AND JOHN A. LIBERTINO

A unique feature of renal cell carcinoma (RCC) is its predilection to involve venous structures. Tumor extension can grow intraluminally along the renal vein and propagate into the inferior vena cava (IVC) up to and including the right atrium and occurs in 4% to 10% of cases. Although this does worsen the prognosis, if tumor spread has not occurred to the lymph nodes or otherwise metastasized, these tumors can be controlled surgically using a variety of approaches.

STAGING

In 2010, the American Joint Committee on Cancer published updated guidelines on RCC staging. In those guidelines, as pertains to intracaval tumors, pathologic T3a lesions are those that involve the renal vein or its segmental branches or invades renal sinus or perirenal fat. Pathologic T3b lesions are those that involve the IVC with the most proximal extent below the diaphragm, and T3c lesions are those that extend above the diaphragm. These classifications were modified according to research that showed that proximal extent of tumor thrombus had significant effect on cancer-specific survival (1) and has since been confirmed in larger multi-institutional studies (2).

Various other surgical staging systems have been proposed to define the extent of tumor thrombus and aid in surgical planning including the Neves system, the Novick system, and the Hinman system. At our institution, the Neves system is found to be a rationally organized and commonly used. It is broken down by level of cephalad extent of tumor (Fig. 4.1).

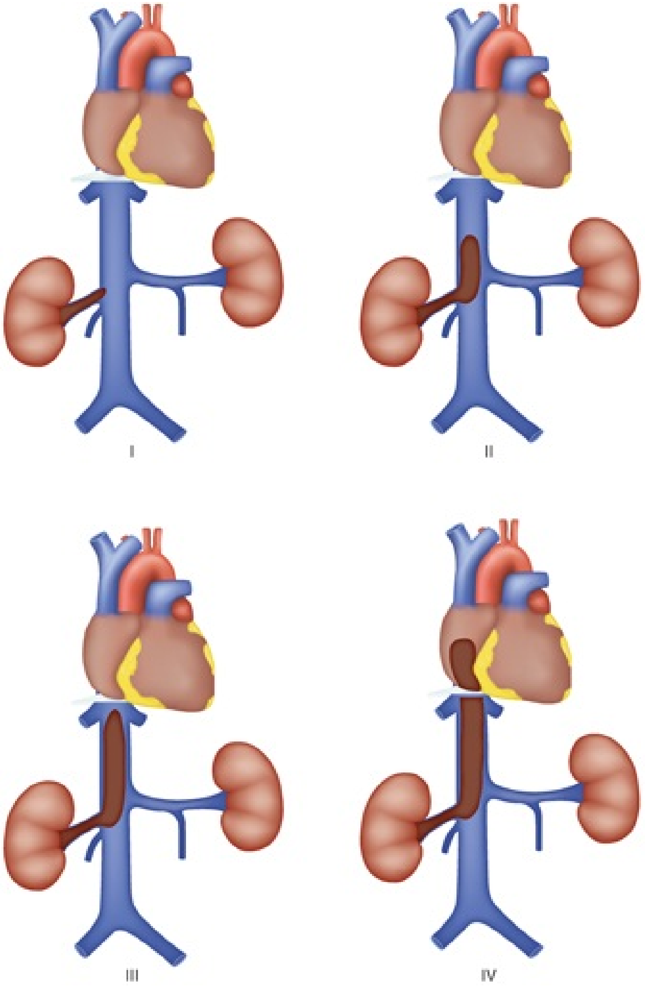
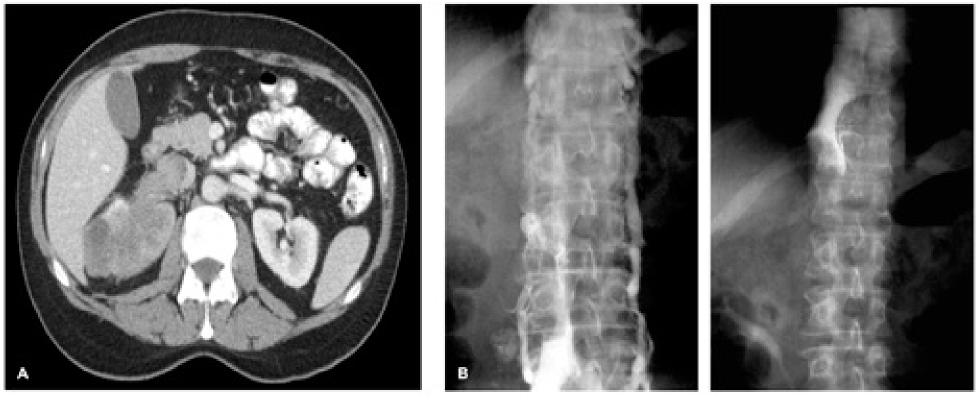


FIGURE 4.1 Classification of venous tumor thrombus extension—level I renal vein, level II infrahepatic IVC, level III retrohepatic IVC, and level IV supradiaphragmatic IVC. (Adapted with permission from Wang GJ, Carpenter JP, Fairman RM, et al. Single-center experience of caval thrombectomy with renal cell tumor extension into the inferior vena cava. *Vasc Endovascular Surg* 2008;42(4):335–340. Copyright © 2008, SAGE Publications.)

DIAGNOSIS

Preoperative imaging is critically important to plan the surgical approach and determine the need for cardiopulmonary bypass prior to resection. A variety of modalities exist to accurately diagnose the extent of tumor thrombus. Three-dimensional multiplanar computerized tomography can provide not only information about the extent and level of tumor thrombus but also the presence of collateralizations, lumbar venous anatomy, renal arterial anatomy, local surgical staging, and anatomic factors. Magnetic resonance venography is another useful technique routinely used to evaluate venous thrombus involvement (Fig. 4.2A–C). Transthoracic and transabdominal ultrasound can also be useful in patients who cannot undergo abdominal imaging. Finally, for patients undergoing renal artery angioembolization prior to resection, traditional inferior venacavography can be performed simultaneously. This, however, has limited benefit for evaluating the cephalad extent in cases of complete occlusion of the IVC.



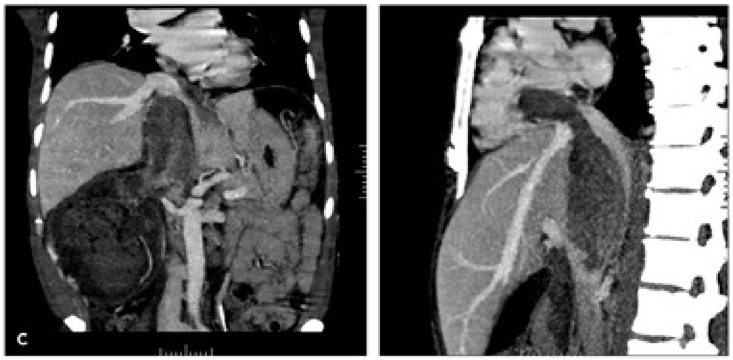


FIGURE 4.2 A: Contrast-enhanced upper abdominal computerized tomography with thrombus seen in renal vein. **B:** Preoperative cavogram demonstrating filling defect at the T10 level consistent with tumor thrombus in a patient with a large right renal mass. **C:** Coronal and sagittal magnetic resonance imaging scan demonstrates tumor extending to the level of the diaphragm (left) and further into the right atrium (right).

PREOPERATIVE ANGIOEMBOLIZATION

Renal artery embolization has evolved over the years from initially a palliative procedure to a preoperative adjunct to resection of locally advanced renal tumors. Preoperative renal angioinfarction facilitates dissection of the renal tumor as a result of local tissue edema from hypoxia and tissue necrosis. It also limits the amount of manipulation on the renal vein prior to resection because the vein may be transected prior to controlling or occluding the renal artery. It has been postulated that preoperative angioinfarction may decrease the extent of tumor thrombus while minimizing venous collateralization (3). It is the practice of the senior author to routinely perform preoperative angioembolization prior to surgical resection for RCC with venous thrombus involvement.

SURGICAL APPROACH

Surgical approaches to intracaval tumor thrombi are subject to extent of IVC involvement, body habitus, prior surgical history, and surgeon comfort. The goal of any surgical approach should be to maximize exposure of the great vessels and involved renal tumor. Tumors that involve the renal vein only typically can be managed with a thoracoabdominal incision in a fashion similar to organ-confined tumors. For right-sided infrahepatic tumors, a thoracoabdominal approach can still be used and provides adequate exposure of the infrahepatic IVC. Left-sided infrahepatic, all retrohepatic, and all supradiaphragmatic IVC tumor thrombi are approached using an upper abdominal chevron incision with the addition of either a median sternotomy or more recently a mini-access right fourth rib parasternal incision to access the right atrium and supradiaphragmatic IVC.

After induction of general anesthesia and intubation intraoperative monitoring is performed by placing a right internal jugular central venous MAC two-lumen catheter. Through this, a Swan-Ganz pulmonary artery catheter is introduced and floated into the pulmonary artery. Two large-bore peripheral intravenous lines are placed and if peripheral access is poor, a second 9Fr central venous catheter is placed in the contralateral great vessels. A Belmont Rapid Infuser is available in cases of large volume blood loss, and two Cell Saver devices are used to recycle blood products.

Prior to incision, transesophageal echocardiography is performed to evaluate for tumor thrombus propagation that would necessitate cardiopulmonary bypass. Accurate intraoperative hemodynamic monitoring is critical during the procedure, especially when using cardiopulmonary bypass. Another useful device for intraoperative monitoring is the real-time electrical impedimetric monitoring of blood coagulation factors, which allows for continuous resuscitation of blood loss and coagulopathy by anesthesia.

For tumor thrombus at or above 2 cm below the hepatic vein confluence, cardiopulmonary bypass and deep hypothermic cardiac arrest are routinely used to ensure a bloodless field in resecting these tumors. Although this approach is associated with risks of systemic anticoagulation and central nervous system impairments, it is the opinion of the senior author that these risks are justified to provide adequate access of the cephalad portion of tumor thrombus to prevent embolization or inadvertent disruption of the caval–atrial junction in milking techniques.

Infrahepatic Inferior Vena Cava Thrombus

The patient is positioned in the supine position with arms extended at 90 degrees. After induction of general anesthesia and placement of anesthetic intraoperative monitoring device, a Foley catheter is placed and the abdomen from the xiphoid to pubis is clipped free of hair and prepped with 2% chlorhexidine ChloraPrep solution from the lower rib cage to the pubis.

For right-sided tumors, a thoracoabdominal approach is used. For left-sided tumors, a chevron incision is made from the tip of the 11th rib to the tip of the contralateral 11th rib. For both right- and left-sided tumors, the initial portion of the procedure is controlling the IVC with limited manipulation to prevent possible dissemination of tumor thrombus. The peritoneum is entered, and the ascending colon and hepatic flexure are mobilized medially along the line of Toldt. The duodenum is kocherized exposing the right renal vein and IVC. A Bookwalter retractor is the used to provide maximal exposure. A series of short body wall retractors are placed at the 9 o’clock, 6 o’clock, and 4 o’clock position of the wound to retract oblique musculature, subcutaneous tissue, and skin. The duodenum and colon are retracted medially by using a malleable retractor with a moistened laparotomy pad. The liver is retracted cephalad either using a Harrington retractor or malleable retractor with laparotomy pads. Care must be taken to avoid damage to the porta hepatis.

The IVC is then exposed. The cephalad extent of tumor thrombus is palpated with care to prevent embolization from overzealous palpation. The right gonadal vein is identified and ligated between silk ties to prevent troublesome back bleeding during cavotomy and thrombectomy. For tumor at the junction of the renal vein and IVC or with a small caval extension, a DeBakey clamp is applied to the IVC, the thrombus removed, and the IVC is reconstructed (Fig. 4.3A–D). With larger caval extension, circumferential dissection of the IVC as well as the right and left renal vein is carried out so as to provide for placement of Rummel tourniquets. Lumbar veins as well as minor hepatic veins are identified and ligated to prevent back bleeding. Many times, renal angioembolization will produce an inflammatory response that precludes the need for arterial mobilization, and ligation of the renal artery is deferred until after IVC thrombectomy is performed. Complete occlusion of the renal artery is confirmed, however, by visually inspecting the renal vein as well as palpating the renal artery for persistent flow. If any doubt exists regarding the completeness of arterial occlusion, then renal artery dissection must take place prior to cavotomy to prevent unnecessary bleeding.

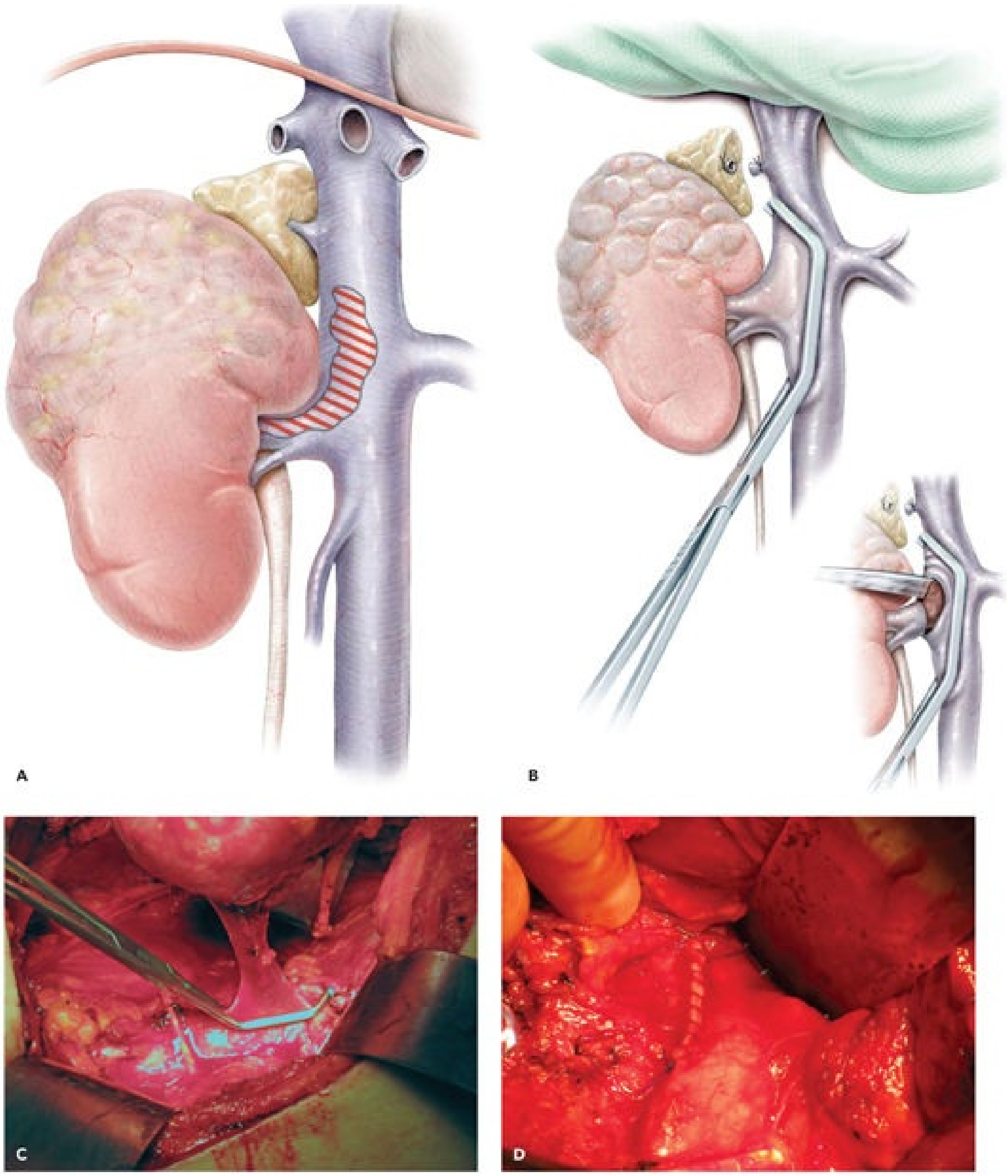


FIGURE 4.3 A and B: Removal of small intracaval tumor thrombus by side clamping of junction between renal vein and IVC. (Reprinted with permission from Bachmann A, Seitz M, Graser A, et al. Tumour nephrectomy with vena cava thrombus. *BJU Int* 2005;95:1373–1384. Copyright © 2005, John Wiley and Sons.) C and D: DeWeiss clamp applied to sidewall of cava for removal of renal vein thrombus with small intracaval extension.

Once adequately exposed, Rummel tourniquets are placed on the cephalad extent of the IVC, the contralateral renal vein, and caudal portion of the IVC (Fig. 4.4A–C). They are the occluded in rapid succession in the order of cephalad, vein, and caudal. An anterior longitudinal cavotomy is performed using curved scalpel followed by Potts scissors. This incision follows a curvilinear tract to incorporate the ipsilateral renal ostium, which will be removed en bloc with the complete specimen. The thrombus is then freed from the caval wall using Penfield neurosurgical spatulas. Any areas of caval wall invasion must be resected. If <50% of caval wall is involved, this may then be closed primarily. In cases where >50% of the wall is involved, then reconstruction using either synthetic polytetrafluoroethylene vascular patch or with a variety of bioprosthetic or autologous materials (pericardium, saphenous vein graft, bovine pericardium). The IVC is gently flushed with heparinized saline and evaluated for any residual fragments. The cavotomy is closed with continuous 4-0 polypropylene sutures. The inferiormost Rummel tourniquet is released first to flush the cava of blood and limit the risk of air embolus.

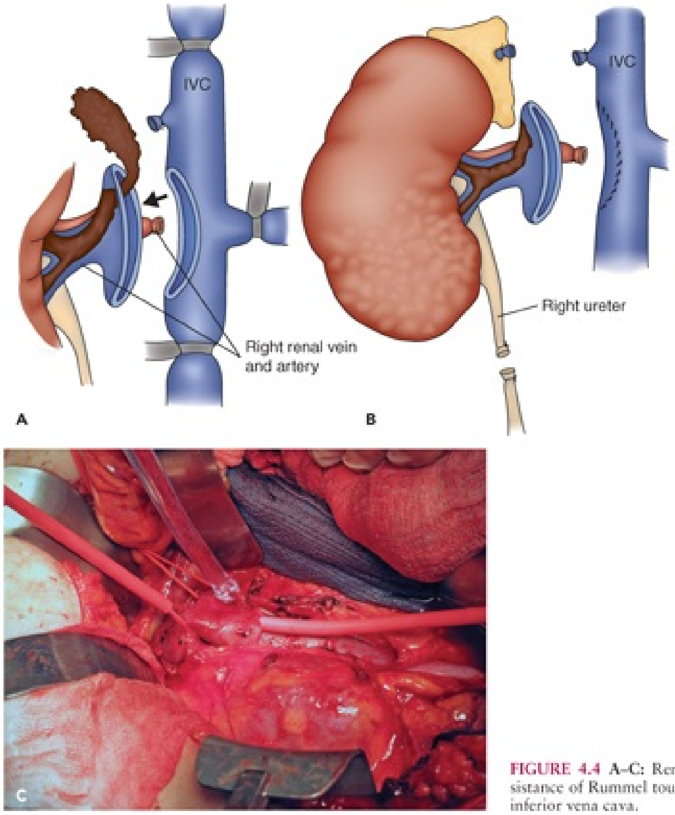


FIGURE 4.4 A–C: Removal of infrahepatic tumor thrombus with assistance of Rummel tourniquets avoiding cardiopulmonary bypass. *IVC*, inferior vena cava.

Once the tumor thrombus is removed from the vena cava, radical nephrectomy and lymphadenectomy (if indicated) can proceed. For tumors of the right kidney, exposure is unchanged. Now that the vein has been divided from the IVC, the right renal artery should be readily exposed. The artery is then divided distal to the angioembolization coils with two clips and silk suture ligature. The kidney is then mobilized within Gerota fascia posteriorly down to the psoas fascia taking as much pararenal fat as possible. Superiorly, the kidney and adrenal are mobilized from the hepatorenal ligamentous attachments. A large curve-shaped DeBakey clamp is passed along the superior portion of the adrenal gland to gain control of the phrenic vessels, which are divided and ligated using a 0 silk suture. Finally, the ureter is ligated with 2-0 Vicryl or silk suture and the specimen removed en bloc.

For left-sided tumors, once the left renal vein is disarticulated from the IVC and thrombus removed, the left renal pedicle must be controlled. To achieve this, the splenic flexure and the descending colon are mobilized, and the descending colon is reflected medially with care taken to avoid injury to the tail of the pancreas, or spleen. The left renal hilum is identified. Draining into the left renal vein, the adrenal vein and gonadal veins are identified and ligated with 0 silk suture. Once the vein is freed from its surrounding tributaries, the left renal vein is delivered from its insertion point on the IVC to the left side of the retroperitoneal space. To do this, a finger is placed along the left renal vein over the aorta. The surgeon can carefully palpate the anterior surface of the aorta and the inferior surface of the superior mesenteric artery (SMA) as the vein crosses beneath this latter structure. With gentle manual traction, the vein is delivered safely from between these vessels. The kidney is then mobilized within Gerota fascia. The adrenal gland is mobilized en bloc and superior attachments are divided using a large C-shaped clamp and silk suture ligature. The renal artery is next divided. We recommend approaching the left renal artery posteriorly to avoid inadvertent ligation of the SMA. To do this, the kidney is elevated medially on its vascular pedicle and the artery is identified posterior to the left renal vein and lateral to the left side of the aorta. The artery is divided with large Hem-O-Lok clips and 0 silk suture ligature. Occasionally, tumor-associated inflammatory changes might preclude precise vascular isolation, and a vascular stapler can be used. The ureter is then ligated and the kidney and adrenal gland, contained within Gerota fascia, are removed.

Retrohepatic Inferior Vena Cava Thrombus

Tumors that are reaching 2 cm below the hepatic veins may still be approached without circulatory bypass provided that proximal control of the IVC can be obtained (Fig. 4.5A). To access the retrohepatic IVC, the Langenbuch maneuver is performed by incising the peritoneal reflections attaching the liver to the diaphragm, namely, the coronary ligament and right or left triangular ligaments, the ligamentum teres, and the falciform ligament. This allows mobilization of the liver cephalad and medial exposing the retrohepatic cava (Fig. 4.5B). Minor hepatic veins may be divided using silk ties. Rummel tourniquets are applied, and the caval thrombus extracted (Fig. 4.5C). The porta hepatis is accessed via the foramen of Winslow and prior to cavotomy, the Pringle maneuver can be performed if necessary to prevent significant hepatic venous inflow and blood loss.

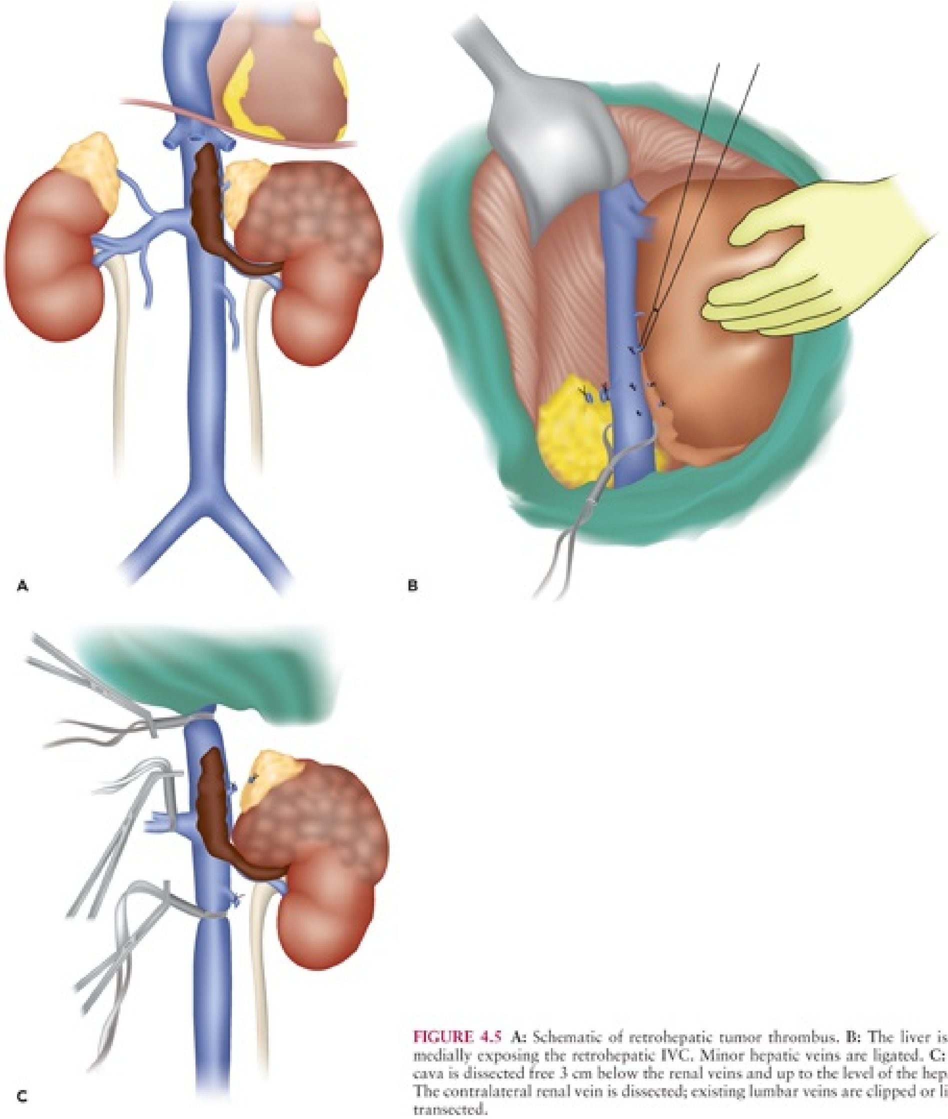


FIGURE 4.5 **A:** Schematic of retrohepatic tumor thrombus. **B:** The liver is retracted medially exposing the retrohepatic IVC. Minor hepatic veins are ligated. **C:** The vena cava is dissected free 3 cm below the renal veins and up to the level of the hepatic veins. The contralateral renal vein is dissected; existing lumbar veins are clipped or ligated and transected.

Supradiaphragmatic and Atrial Thrombus

When tumor thrombus reaches above the level of the diaphragm (Fig. 4.6A), then cardiopulmonary bypass with deep hypothermic circulatory arrest is used to provide maximal exposure to the supradiaphragmatic cava and right atrium and allow for tumor resection in a bloodless field. Two approaches have been developed to accomplish this maneuver, the traditional median sternotomy and the minimal access technique.

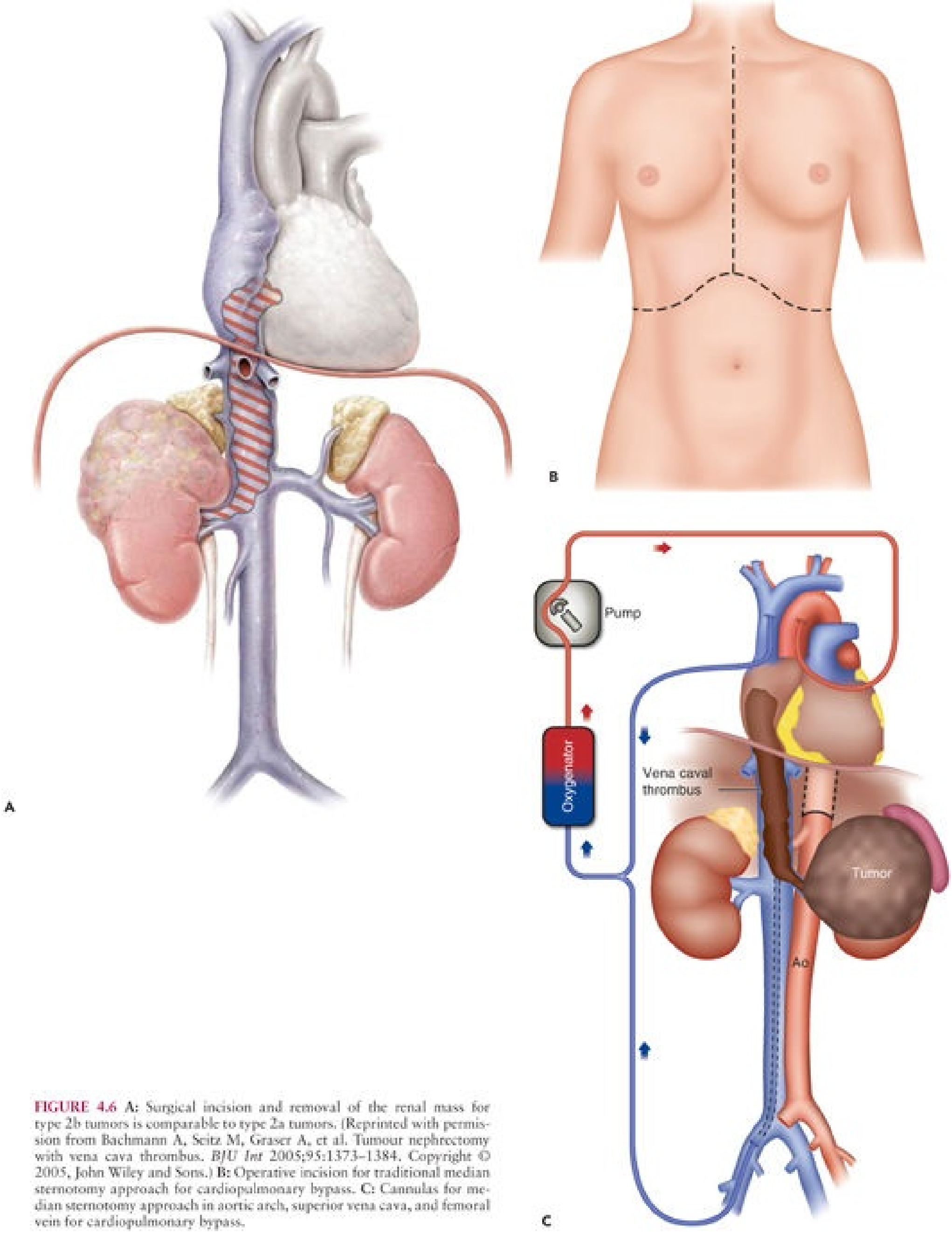


FIGURE 4.6 **A:** Surgical incision and removal of the renal mass for type 2b tumors is comparable to type 2a tumors. (Reprinted with permission from Bachmann A, Seitz M, Graser A, et al. Tumour nephrectomy with vena cava thrombus. *BJU Int* 2005;95:1373–1384. Copyright © 2005, John Wiley and Sons.) **B:** Operative incision for traditional median sternotomy approach for cardiopulmonary bypass. **C:** Cannulas for median sternotomy approach in aortic arch, superior vena cava, and femoral vein for cardiopulmonary bypass.

Traditional Median Sternotomy

As with infrahepatic IVC thrombus, the initial steps involve isolating and exposing the IVC. A chevron incision is made, the ascending colon is reflected medially, and the duodenum is kocherized. The liver is displaced cephalad exposing the retrohepatic portion of the IVC. The contralateral renal vein and caudal portion of the IVC are dissected free with again minimal traction on the IVC to prevent embolization. Meticulous hemostasis is obtained prior to systemic heparinization.

A midline sternal incision is made by the cardiothoracic team, and pericardial access is obtained. Systemic heparinization with low-molecular-weight heparin is administered, and the pericardium is suspended from the wound edges, and arterial and venous cannulas are placed in the ascending aorta and the right atrial appendage. Once vascular access is obtained, the patient is cooled and cardiopulmonary bypass is initiated.

Minimal Access

To limit the morbidity associated with a median sternotomy incision, a minimally invasive approach has been developed based on the approach originally described for aortic valve replacement by Cosgrove in 1996 (4,5). A right infraclavicular incision is made and carried down through subcutaneous tissues and pectoralis musculature. This right axillary artery is encountered and encircled with vessel loops proximally and distally. A right parasternal 2-inch incision is made over the fourth costal cartilage. This incision is carried down through the pectoralis musculature. The fourth costal cartilage is resected and the mammary artery and vein are ligated between ligatures and clips. The pericardium is opened and holding sutures of 0 silk are placed (Fig. 4.7). Systemic heparinization with low-molecular-weight IV heparin is administered. An 8-mm arteriotomy in the right subclavian artery is made and a Dacron tube graft is sutured in place using a running 5-0 Prolene suture. A purse-string suture of Ethibond is placed in the right atrium, and a two-stage venous cannula is introduced into the atrium and directed into the superior vena cava to avoid tumor thrombus in the IVC. Once vascular access is obtained, the patient is cooled to 17°C and formal circulatory arrest is commenced by administering cardioplegic solution. The patient is exsanguinated, and the head is protected and cooled in bags of ice.

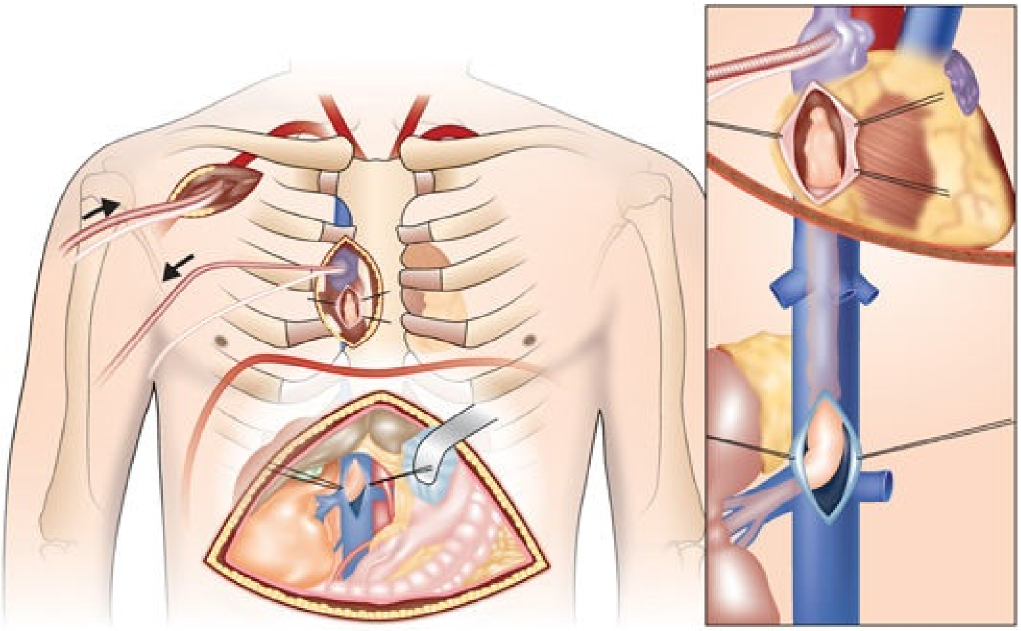


FIGURE 4.7 Schematic of minimal access technique for cardiopulmonary bypass.

A formal right atriotomy is made as well as an incision in the anterior vena cava from below. Tumor thrombus is removed from above and below by the cardiothoracic and urologic teams working in concert (Fig. 4.8). Once thrombus is removed, a gauze pad can be passed through the atriotomy from above down into the cavotomy below using a “shoe shine” maneuver to clear all tumor thrombus. Flexible cystoscopy and Fogarty balloons can be used to ensure complete thrombus removal. Once thrombectomy is complete, and the cavotomy and atriotomy is closed, the patient is rewarmed and the heart is cardioverted to regular rhythm. Protamine is used to reverse the heparin effects, and while rewarming takes place, the nephrectomy portion is completed as mentioned earlier. The right atrium is closed with prior purse-string suture and reinforced with pledgeted mattress sutures of Prolene. The arterial graft is amputated and the stump oversewn with a double layer of running 4-0 Prolene. A Blake drain is then placed in the pericardial space and a 28Fr chest tube is placed in the right pleural space. The fourth costal cartilage is reaffixed with a figure-of-eight Vicryl stitch, and the remainder of musculature, subcutaneous tissue, and skin are reapproximated with absorbable Vicryl sutures.

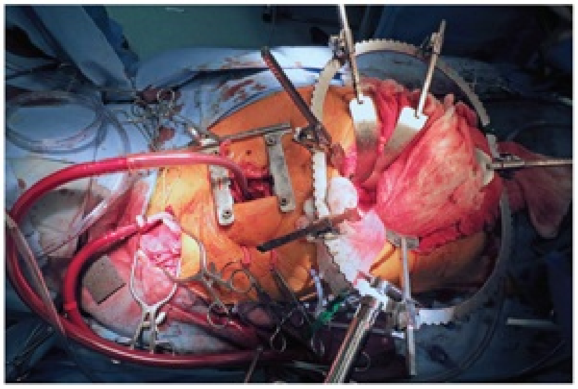


FIGURE 4.8 Minimal access incision for cardiopulmonary bypass using right parasternal and right supraclavicular incisions. Note the abdominal chevron incision below.

Venovenous Bypass

In patients with minimal supradiaphragmatic thrombus, venovenous bypass with a caval–atrial shunt is one alternative to cardiopulmonary bypass. Venovenous bypass can also be useful in patients who cannot tolerate IVC clamping or require significant IVC reconstruction. The vena cava is controlled at the infrarenal level and at the level of both renal veins as well as proximal tourniquet around the intrapericardial portion of the IVC. Cannulas can be placed in the right atrium or axillary vein and the femoral veins and bypass initiated prior to cavotomy. Bleeding from the hepatic venous system is managed with a Pringle maneuver or cross-clamping the hepatic veins. The Pringle maneuver can be used for up to 45 minutes before liver metabolism is significantly affected. Although this technique avoids cardiopulmonary bypass and circulatory arrest, the incidence of hepatic venous bleeding can occasionally be significant.

NEOADJUVANT TARGETED THERAPY

One interesting approach to managing intracaval tumors in RCC is to use neoadjuvant tyrosine kinase inhibitors to downstage the tumor and avoid the need for cardiopulmonary bypass. Horn et al. (6) have reported the use of neoadjuvant sunitinib in five patients with level III and level IV RCC. In their series, four patients had downstaging of their disease, and one case negating the need for cardiopulmonary bypass. Individual case reports of neoadjuvant sunitinib have also shown reduction in tumor size and stage (Fig. 4.9) (7). However, these results have yet to be validated in other larger series and conflicting reports of disease progression despite neoadjuvant targeted therapy puts these findings into perspective (8). However, the concept of neoadjuvant therapy to facilitate surgical removal remains intriguing.

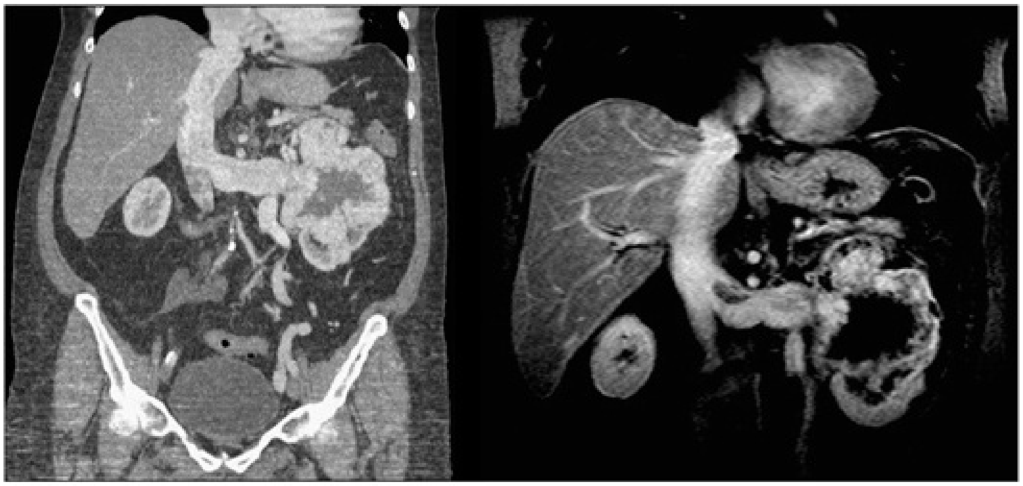


FIGURE 4.9 Preoperative downstaging of RCC with IVC tumor thrombus using neoadjuvant tyrosine kinase inhibitor. Prior to therapy, an atrial tumor thrombus (left) is reduced to an infrahepatic thrombus obviating the need for cardiopulmonary bypass and circulatory arrest.

COMPLICATIONS

Given the extensive nature of both the abdominal and thoracic portions of intracaval tumor thrombectomy and radical nephrectomy, even in experienced hands complications are not uncommon. The most common types of complications include bleeding complications, pulmonary complications, and abdominal complications.

Pulmonary complications include pneumonia, atelectasis, pulmonary embolus, and injury to lung parenchyma either using thoracoabdominal incisions or in accessing the right atrium and intrathoracic cava. Postoperative pulmonary toilet with incentive spirometry, bronchodilators, and chest physiotherapy can help prevent atelectasis and pneumonia. When cardiothoracic surgical involvement is employed, then standard 26Fr chest tubes are placed in the pleural space and removed on postoperative day 2. When a thoracoabdominal incision is used only, then smaller Dart chest tubes are employed. We have found that when compared to traditional median sternotomy, the minimal access technique is associated with significant decreases in postoperative complications for patients undergoing cardiopulmonary bypass and circulatory arrest, particularly pulmonary complications including prolonged mechanical ventilation (9).

Vascular complications are not uncommon given the nature of the vascular dissection. When cardiopulmonary bypass is not employed, lumbar venous back bleeding from uncontrolled lumbar vessels can be significant at times. If this occurs, an Allis clamp can grasp the open vessel intraluminally and a counterclockwise twist can be used to stop acute bleeding. A Fogarty balloon can also occlude the lumen of an open lumbar vessel. Avulsed lumbar vessels can be controlled using a pediatric hemostat and pediatric right angle to control the open vessel until it can be oversewn with 3-0 silk.

It is critical to emphasize the importance of understanding the proximity of the SMA to the left renal vein, particularly in left-sided tumors, as ligation of this vessel will carry dire consequences. For this reason, we advocate identifying the left renal artery from a posterior approach when ligating it so as not to misidentify the SMA.

Abdominal complications can include injury to any adjacent structures such as the liver, spleen, pancreas, and duodenum as well as colon or small bowel. These complications are occasionally unavoidable when large renal tumors abut or invade contiguous structures. Liver lacerations are best managed by using the argon beam coagulator to the injured site. The same may apply to small lacerations of the spleen; however, splenectomy may be required when larger injuries occur. Pancreatic injuries recognized at the time of surgery require that the capsule of the pancreas be closed with nonabsorbable suture and drained with a Jackson-Pratt device. Delayed recognition of a pancreatic leak is managed by a percutaneous drain, hyperalimentation, and somatostatin until the drainage subsides.

OUTCOMES

Given the complexity of these cases, it is not surprising that perioperative mortality does occur with perioperative mortality rates that range from 5% to 10% in contemporary series. When nodal metastases are involved, overall survival is severely impacted. Published series have seen survival rates ranging from 5% to 28%. When nodal or distant metastases are absent, however, then overall survival rates are reasonable, ranging from 40% to 60% of patients. In our series, we have found 5-year cancer-specific survival rates on average of 53% with 65% survival of patients with isolated renal vein involvement to 40% survival of patients with advanced stage intracaval tumor thrombi.

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CHAPTER 5 ■ DONOR NEPHRECTOMY: LAPAROSCOPIC TECHNIQUES

JIM C. HU AND ERIC G. TREAT

According to the National Institute of Diabetes and Digestive and Kidney Diseases, more than 871,000 people were being treated for end-stage renal disease, with 398,861 having some form of dialysis and 172,553 having a working transplanted kidney at the end of 2009 (1). The Scientific Registry of Transplant Recipients (SRTR) reported 16,811 kidney transplants were performed in 2011; 5,768 were from living donors (2).

Laparoscopic donor nephrectomy was first performed in 1995 (3). The generally accepted benefit of decreased hospital stay and postoperative pain associated with laparoscopic versus open donor nephrectomy may facilitate the acceptance of a unique surgery that leaves the patient in worse health postoperatively.

DIAGNOSIS

Strict guidelines and international standards have established that all donors have complete medical and psychosocial evaluation as well as evaluation by an independent donor advocate (4,5,6). At our institution, patients routinely see a nephrologist, surgeon, psychiatrist, and social worker. Medical evaluation includes a complete history and physical: urine tests: urinalysis, urine culture, 24-hour urinary protein excretion, and glomerular filtration test estimates; blood tests: complete blood count, coagulation screen (partial thromboplastin time, prothrombin time), serum electrolytes, urea, creatinine, liver function tests, fasting serum glucose, glucose tolerance test, lipid panel, and alkaline phosphatase; serology testing: HIV, hepatitis B and C, tuberculosis, syphilis, Epstein-Barr virus, and cytomegalovirus; compatibility testing: blood group type, human leukocyte antigen typing, and cross-matching; cardiopulmonary workup: chest X-ray and electrocardiogram. Other testing is performed as indicated. Every screened donor eventually has a multidetector computerized tomographic angiography/urography with reconstructions for evaluation of the kidneys and vascular anatomy. Any questionable findings on medical, surgical, and psychosocial evaluation are discussed in a multidisciplinary committee prior to proceeding with donation.

INDICATIONS FOR SURGERY

Healthy patients aged older than 18 years are eligible for donation. Medical contraindications to kidney donation are summarized in Table 5.1 (7). The decision-making process may be quite complex and multifactorial.

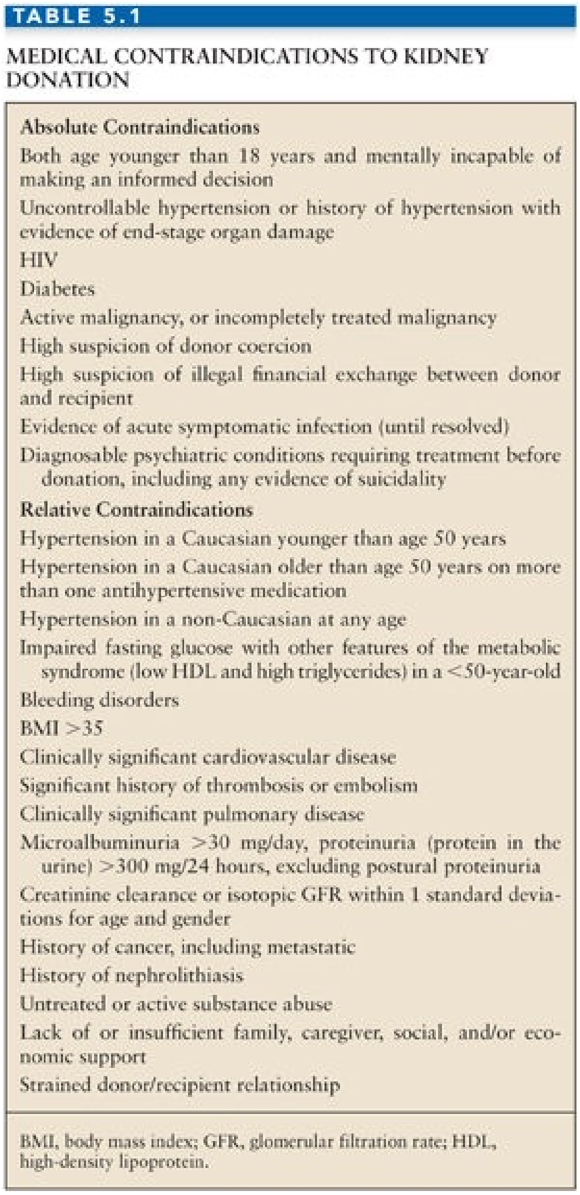

TABLE 5.1

MEDICAL CONTRAINDICATIONS TO KIDNEY DONATION

Absolute Contraindications

- Both age younger than 18 years and mentally incapable of making an informed decision
- Uncontrollable hypertension or history of hypertension with evidence of end-stage organ damage
- HIV
- Diabetes
- Active malignancy, or incompletely treated malignancy
- High suspicion of donor coercion
- High suspicion of illegal financial exchange between donor and recipient
- Evidence of acute symptomatic infection (until resolved)
- Diagnosable psychiatric conditions requiring treatment before donation, including any evidence of suicidality

Relative Contraindications

- Hypertension in a Caucasian younger than age 50 years
- Hypertension in a Caucasian older than age 50 years on more than one antihypertensive medication
- Hypertension in a non-Caucasian at any age
- Impaired fasting glucose with other features of the metabolic syndrome (low HDL and high triglycerides) in a <50-year-old
- Bleeding disorders
- BMI >35
- Clinically significant cardiovascular disease
- Significant history of thrombosis or embolism
- Clinically significant pulmonary disease
- Microalbuminuria >30 mg/day, proteinuria (protein in the urine) >300 mg/24 hours, excluding postural proteinuria
- Creatinine clearance or isotopic GFR within 1 standard deviations for age and gender
- History of cancer, including metastatic
- History of nephrolithiasis
- Untreated or active substance abuse
- Lack of or insufficient family, caregiver, social, and/or economic support
- Strained donor/recipient relationship

BMI, body mass index; GFR, glomerular filtration rate; HDL, high-density lipoprotein.

Relative surgical contraindications to transperitoneal laparoscopic donor nephrectomy include prior abdominal surgery (reoperative abdomen), intraperitoneal mesh, and other general contraindications to transperitoneal laparoscopy; however, most of these (e.g., peritonitis, cirrhosis, bowel obstruction) would have excluded the potential donor from donating based on medical evaluation alone.

Donor renal vascular and urologic anatomy is important in determining which kidney (left or right) to remove. Leaving the donor with the optimal kidney is the primary indication for choosing a particular side. For example, removing a kidney with a cyst, small cortical scar, or similar defect would be preferred. Typically, transplant surgeons prefer a left kidney due to longer renal vein length. The number of renal arteries and veins should also be considered. Having three or more arteries may lead to increased donor or recipient surgical complications or poorer graft outcomes; however, it is no longer considered an absolute contraindication (8,9). Duplicated ureteral anatomy is not contraindicated unless there is underlying renal deficiency of the associated kidney.

ALTERNATIVE THERAPY

Alternative procedures include hand-assisted laparoscopic, single-site laparoscopic, robotic-assisted laparoscopic, and “mini-incision” open and traditional open flank nephrectomy. Some centers have advocated extracting the kidney through a vaginal incision.

SURGICAL TECHNIQUE

Preparation

The patient undergoes a gentle bowel preparation the day before surgery with a clear liquid diet and a magnesium citrate suspension. All patients receive preoperative antibiotics and sequential compression devices (pulsatile stockings) for prophylaxis. After administration of general anesthesia with the patient in supine position, an orogastric tube to decompress the stomach (helpful for optimal splenic reflection during left laparoscopic donor nephrectomy [LDN]) is placed, abdominal hair is clipped, and Foley urethral catheter is inserted. Additionally, the Pfannenstiel incision is marked in the supine position (lower transverse incision approximately 8 cm in length, 3 cm above the symphysis pubis). Marking the incision site prior to positioning alleviates the distortion of gravity from the patient's pannus in keeping the incision midline and cosmetically even.

Positioning

The patient is positioned into a modified flank position (modified lateral decubitus). Starting with the patient supine with the contralateral arm abducted 90 degrees onto an arm board, the surgical team rotates the head, shoulders, torso, hips, and legs approximately 75 to 90 degrees perpendicular on the operating table. An axillary role placed just below the axilla relieves undue pressure on the shoulder and helps prevent brachial plexus injury. A back roll (rolled bedsheet) provides support for the lateral positioning. The inferior contralateral leg is flexed 90 degrees at the knee and the superior ipsilateral leg left straight and padded. We place the ipsilateral arm in a neutral position along the lateral torso in an adducted, anatomic position shown in Figure 5.1. To date, no positioning injury, neurapraxias, or complaints have been noted in patients positioned with the arm in this neutral position at our institution. Moreover, this positioning eliminates the need for an airplane, and if immediate open conversion is required, there is adequate space for a subcostal incision. Alternatively, the ipsilateral arm may be extended and abducted, supported by an airplane armrest over the contralateral arm. This position may limit laparoscopic motion range when panning into the pelvis. A moderate amount of table flexion allows for separation of the iliac crest from the lower rib cage. We minimize table flexion because overall it contributes only little benefit to the dissection and exaggerated flexion may lead to back pain postoperatively. Similarly, we do not elevate the kidney rest. Once positioned, 4-inch cloth tape secures the patient to avoid shifting. After prepping and draping, mannitol 12.5 g is administered intravenously.

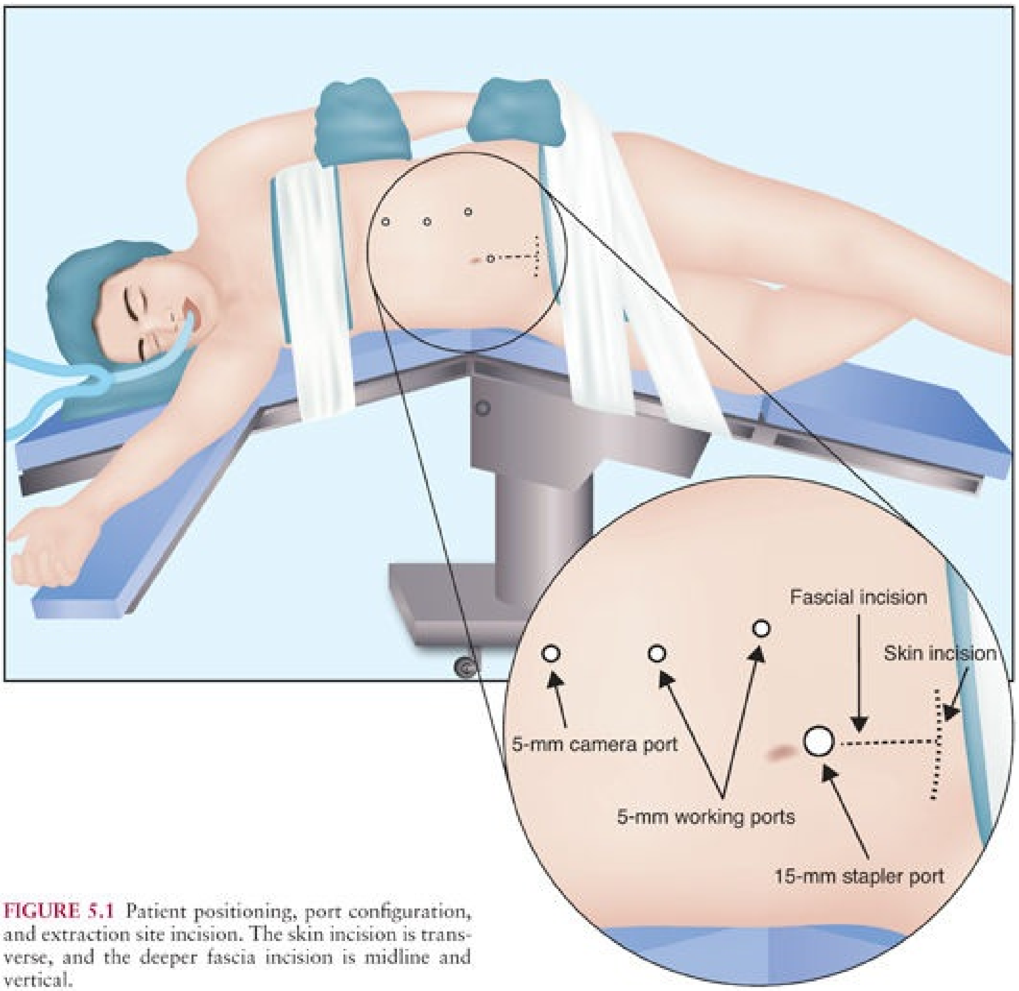

FIGURE 5.1 Patient positioning, port configuration, and extraction site incision. The skin incision is transverse, and the deeper fascia incision is midline and vertical.

Left-Sided Laparoscopic Donor Nephrectomy

Insufflation and Initial Trocar Placement

Pneumoperitoneum is obtained using a Veress needle placed midline and 0.5 cm superior to the umbilicus. Alternative sites, such as Palmer point, 3 cm below the middle of the left costal margin, or an open trocar placement technique may be used if there are concerns for significant adhesions from prior surgery.

After achieving 15 mm Hg of CO_2 insufflation pressure, the laparoscopic trocars are placed along the left rectus margin. We use 5-mm trocars, which obviate the need to close the fascia of the trocar sites with Endo Close devices that often snare the rectus muscle and may result donor discomfort. An optical obturator, 5-mm trocar with a 0-degree scope, is advanced under direct vision at the junction of the rectus border and costal margin (approximately 1 cm inferior to rib). This will serve as the camera port throughout the case. In the absence of satisfactory Veress needle placement and insufflation, we use the aforementioned approach for our initial trocar placement cautiously under direct laparoscopic vision, without pneumoperitoneum.

Once visual access to the peritoneal space is gained, we switch to the 30-degree, 5-mm scope and place the next two 5-mm trocars under direct vision. Figure 5.1 demonstrates the standard linear port configuration. The second 5-mm trocar is placed approximately 9 cm inferior to the initial trocar in the same line along the lateral boarder of the rectus muscle. The third 5-mm trocar is placed approximately 9 cm inferior to the second trocar however is slightly more lateral to the rectus margin by 1 to 2 cm to allow for better triangulation and reach to the kidney's upper pole. This trocar should be positioned in a horizontal plane lateral at approximately the same level as the umbilicus, and if it is too caudad, the range to dissect and reflect the spleen medially may be compromised.

Reflection of Colon and Retroperitoneal Exposure

The surgeon and assistant stand on the patient’s ventral side, the assistant controls the camera and laparoscope through the most cephalad trocar while the surgeon works through the two caudad trocars. Dissection begins with careful inspection of the surrounding anatomy. The stomach needs full decompression with the orogastric tube. A more distended stomach is at greater risk for injury during the lateral dissection of the spleen for medial reflection. The transverse and descending colon are identified, and commonly, the colon and/or omentum at the splenic flexure tend to be tented or have adhesions to the anterior abdominal wall. These are released using sharp dissection; however, care must be taken not to follow this dissection too laterally, which will result in premature release of the lateral attachments of the kidney and inadvertent incision of Gerota fascia, resulting in loss of countertraction during the medial upper pole and hilar dissection.

To gain retroperitoneal exposure, the white line of Toldt is incised approximately 1 cm lateral to the descending colon. In thinner individuals, this is demarcated by the lateral border of the mesenteric fat, which has a more yellowish hue compared to retroperitoneal adipose tissue (Fig. 5.2). The incision is carried caudally to the pelvic brim. Then, moving cephalad over the kidney, care is taken only to incise the peritoneal layer to preserve an anatomic approach and not enter the deeper attachments or Gerota fascia. Inadvertent entry into Gerota fascia over the kidney will obscure the hilar dissection because the fascia (and perinephric fat) will fall medially over the hilum. This incision is carried cranially, 1 cm lateral border of the spleen, well above the kidney. Often the peritoneal tissue overlying the kidney contains vascular supply so we switch to thermal ligation using a LigaSure (Covidien, Norwalk, Connecticut).

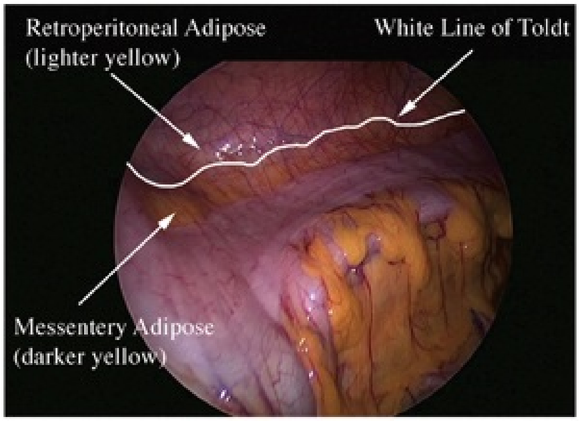

FIGURE 5.2 Descending colon. The incision to expose the left retroperitoneum is made 1 cm lateral to the colon. The mesenteric adipose tissue is typically a darker yellow hue and should be reflected with the colon.

Once the peritoneum is incised, a combination of sharp or blunt dissection is used to release the loose attachments and sweep the peritoneum and mesentery medially. Spinning a laparoscopic Kittner medially while maintaining lateral countertraction with a blunt-tip grasper is very effective to avoid an inadvertent peritoneal window. Additionally, arterial pulsations within the mesenteric fat often serve as a landmark to shift the dissection more laterally. During this maneuver, below the lower pole, the psoas muscle is one of the first structures to be identified lateral to the ureter and gonadal vein and cephalad to the common iliac artery. With more medial reflection of the peritoneum, the gonadal vein is identified coursing just under Gerota fascia. This plane between the peritoneum and Gerota fascia is carried cranially, lateral to the tail of the pancreas and approximately 1 cm lateral to the spleen. The prior incision of the peritoneum needs to be carried up superiorly well above the spleen to ensure the spleen is released medially to allow adequate exposure for the medial upper pole dissection. Care is taken not to release the attachments too far medial to the edge of the adrenal gland because the effects of gravity aid in medial traction via these attachments of the adrenal gland later in the procedure. The stomach may be encountered and must be avoided during this step, and a commonly present prominent diaphragmatic vein serves as the landmark for the upper extent of the dissection (Fig. 5.3).

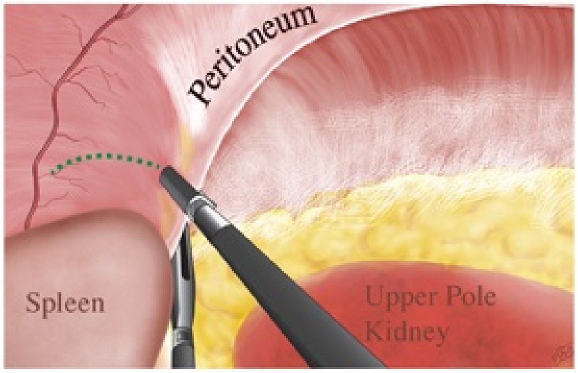

FIGURE 5.3 Reflecting the spleen. The peritoneum is incised well beyond the upper pole of the kidney toward the diaphragm to allow the spleen to reflect medially and expose the entire upper pole. The small inferior diaphragmatic vessels are typically seen and mark the upper extent of the peritoneal incision.

At this point, we approach LDN through a bottom-up approach with corresponding incremental risk. By performing the ureteral dissection early versus late, in case of open conversion, this obviates the need to gain exposure to the ureter toward the pelvis through a small mini-open conversion incision that may need to be enlarged in challenging situations.

Gonadal Vein, Ureter, and Posterior Dissection

After gaining exposure to the retroperitoneum through medial reflection of the peritoneal cavity, we dissect around the gonadal vein at just below the level of the lower pole where the ureter typically crosses underneath (Fig. 5.4). We divide Gerota fascia overlying the gonadal vein in a cephalad direction, directly anterior to the gonadal vein. Extending this dissection of Gerota fascia more cephalad across the renal vein often reveals the confluence of the adrenal and renal vein on the superior edge of the renal vein, more medial to the takeoff of the gonadal vein on the inferior edge of the renal vein. This serves as a key landmark for the later adrenal dissection. The LigaSure is then used to ligate and divide the gonadal vein at the level of the lower pole. We use the LigaSure device due to the consistent ability to ligate the gonadal, adrenal, and lumbar veins, thus avoiding clips near the hilum that may increase the subsequent risk of endovascular stapler misfire on the hilar vessels. Additionally, the LigaSure facilitates blunt dissection without concern of thermal injury.

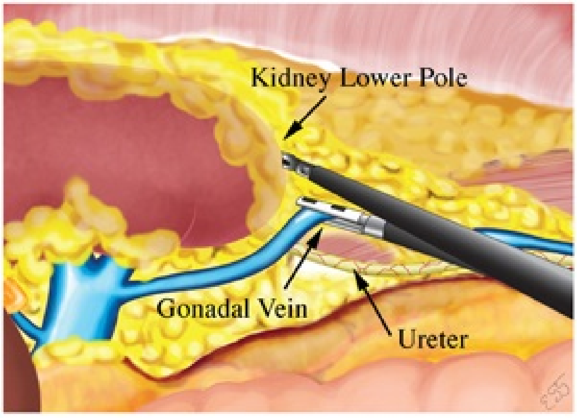

FIGURE 5.4 Division of the gonadal vein. The lower pole of the kidney is the landmark for where the gonadal vein is ligated. The ureter typically crosses underneath at this point as well making for easy identification.

At the point of gonadal vein division, we bluntly dissect onto the psoas muscle fascia, establishing the borders of the ureteral dissection. We routinely ligate the gonadal vein just below the level of the lower pole without a difference in recipient ureteroneocystostomy complications. Moreover, others have shown that this is associated with less postoperative ipsilateral varicocele discomfort in male donors. Carefully elevating the fatty tissue lateral to the ureter and sweeping the ureter down, we continue to divide the lateral attachments down to the level of the pelvic brim. Attention is given to dissect superficial to the psoas muscle fascia, as sensory nerves for the genitofemoral nerve may be damaged with dissection underneath this fascial layer, resulting in a deficit of ipsilateral anterior thigh sensation. Then, with gentle upward tension on the ureter, the plane between the ureter and gonadal is divided using the LigaSure and blunt downward sweeping motions. Care is taken not to strip the ureter of its blood supply. The ureteral dissection ceases at the common iliac artery, but the ureter is not divided until after hilar vessels are divided for two reasons. First, it provides a point of fixation during hilar division; and second, premature division leads to greater subsequent effort to keep track of the ureter and prevent it from flopping into areas of dissection.

Next, with careful elevation and release of the posterior attachments of the kidney bluntly, the LigaSure is used to dissect medial to the proximal gonadal vein stump toward the renal vein (lateral release results in the gonadal vein stump flopping and obstructing subsequent hilar dissection); however, this dissection ceases before potential lumbar veins are encountered typically arising from a similar point along the renal vein as the confluence of the gonadal and renal vein. The 30-degree scope is angled to visualize behind the kidney toward the upper pole while the kidney is then elevated off the psoas and quadratus muscle fascia with largely blunt dissection. This release enables maximal stretching of the hilar vessels to ensure maximal vessel length when subsequently stapled.

Upper Pole Dissection and Release of the Adrenal Gland

After reflecting the tail of the pancreas away from the medial edge of the upper pole (typically done when exposing the retroperitoneum), we enter Gerota fascia, dissecting into the perinephric fat slightly lateral to the edge of the adrenal. Often, the earlier made incision in Gerota fascia started at the lower pole to identify the adrenal vein at its confluence with the renal vein can simply be carried cranially along the adrenal edge. As the lateral edge of the adrenal gland is identified and dissected away from the kidney, the dissection plane is carried as medial as possible along the lateral edge of the kidney to prevent injury to hilar branches to the upper pole. Using a grasper in the surgeon’s left hand to create tension by holding the lateral edge of the adrenal medially and upward greatly facilitates this dissection (Fig. 5.5). Great care is taken to carefully ligate this tissue to avoid inadvertent upper pole renal artery injury. This dissection is carried down to the posterior body wall muscle (quadratus lumborum) and extended superolaterally, resulting in complete release of the upper pole of the kidney away from the spleen. The adrenal vein is dissected out to allow ligation and division. Then, the upper edge of the renal vein proximal to the adrenal vein stump is released with careful blunt dissection to prepare the exit site of the endovascular stapler jaw.

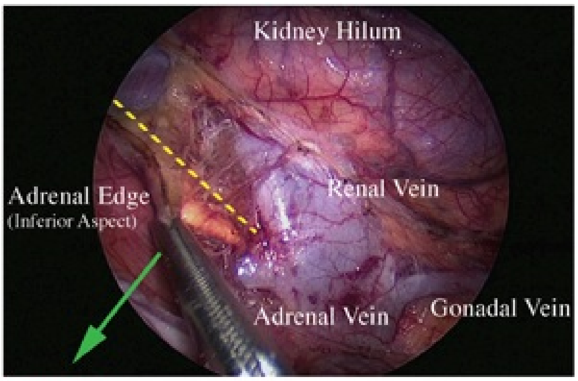

FIGURE 5.5 Adrenal dissection. Careful traction of the adrenal gland anterior, medial and inferior (*green arrow*) allows for exposure of the lateral border (*yellow dashed line*) of the adrenal gland for dissection and release of the kidney's upper pole.

Pfannenstiel Extraction Site, Ligation of Lumbar Veins, and Hilar Dissection

At this point, we coordinate with the recipient surgeon prior to creation of the extraction site to minimize cold ischemia time. The second mannitol of 12.5 g dose is given intravenously. The surgeon makes the horizontal skin incision, marked prior to positioning, continuing down to the anterior rectus sheath. The fascia is then cleared superiorly toward the umbilicus and inferiorly, undermining the skin and subcutaneous adipose tissue, to allow for a vertical midline incision through the fascia, splitting through the bellies of the rectus muscle (Fig. 5.6). The 30-degree scope view of the convergence of the medial umbilical ligaments facilitates identification of the midline, which is always higher than anticipated when landmarking with surface anatomy due to the effect of gravity on the pannus. A cephalad vertical fascial incision is made to accommodate the 15-mm trocar, and 1-cm bridge of fascia is left intact to hold the trocar circumferentially then extended caudal to total approximately 12 cm to allow for quick extraction of the donor kidney. The fascial bridge supports the 15-mm trocar and prevents loss of pneumoperitoneum.

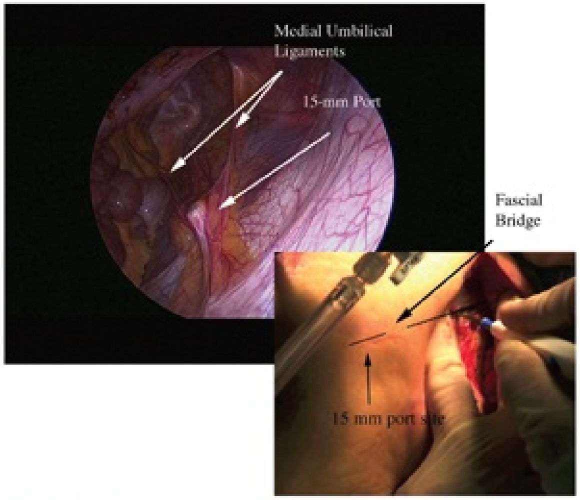

FIGURE 5.6 Low transverse incision. The patient's midline is easily found by viewing the medial umbilical ligaments. A small 1-cm fascial bridge is created when making the vertical fascial incision to prepare the extraction site. The bridge supports the 15-mm trocar and maintains pneumoperitoneum. When the kidney is in the retrieval bag and ready to remove, the bridge is easily transected with cautery, thereby minimizing warm ischemia time.

After completion of the extraction site, the kidney is gently elevated, placing the hilum on tension and the lumbar veins are dissected out, ligated, and divided with the LigaSure to maximize hilar vessel length. Next, the laparoscopic suction tip is passed through the 15-mm extraction site trocar (to simulate the angle of the endovascular stapler) and slid over the aorta behind the renal vein, entering and exiting proximal to the gonadal and adrenal vein stumps, respectively. Formerly, we meticulously dissected out the renal artery to its origin from the aorta; however, this was associated with an increased risk of lymphocele and potential bleeding. Currently, we thin out a pedicle comprising the renal artery as low as possible onto the aorta, using care to leave lymphatic and neurovascular tissue on the aorta. This made the dissection more efficient with less risk. Prior to division of the hilar vessels, the lateral attachments of the kidney are divided with the LigaSure, and the kidney is freed completely with the exception of the hilum and ureter.

Stapling the Hilum and Extraction of the Donor Kidney

Again, we coordinate with the recipient surgeon prior to extracting the kidney for exchanges within the hospital. The surgeon elevates the kidney by using two blunt-tip instruments in the two more caudad 5-mm trocars (Fig. 5.7). The assistant holds one of these blunt-tip instruments (along with the camera) while the surgeon holds the lower one and uses the laparoscopic articulating endovascular GIA stapler (Covidien, Norwalk, Connecticut) with vascular 60-mm loads to divide the renal artery followed by the vein, through the previously established channel. Alternatively, a liver retractor placed through a fourth 5-mm trocar in the anterior axillary line, will elevate the upper pole, however will require an additional trocar placement. Additionally, although some institutions prefer the TA laparoscopic stapler due to the theoretical advantage of gaining a millimeter from the absence of staple lines on the specimen side, the need to use the laparoscopic scissors to cut distal to the staple line is an extra step that may prolong ischemia time compared to the firing and cutting of an endo GIA stapler, and there is additional iatrogenic risk of using scissors and/or cutting a serrated edge of the vessel that must be subsequently trimmed. Next, the ureter is tented upward and a large Weck clip (Teleflex, Research Triangle Park, North Carolina) is applied on the ureter at the level of the common iliac artery before sharp division proximal to the clip. A 15-mm laparoscopic bag is then placed medial to the kidney, allowing gravity to aid it falling in along with a laparoscopic grasper handling the perinephric fat. Prior to cinching the laparoscopic specimen bag, care is taken to ensure that the entire kidney and ureter are completely contained. Electrocautery is used to divide the fascial bridge, preperitoneal fat and peritoneum. Once extracted, the kidney is removed from the bag and immediately submerged in ice. The staple lines are carefully cut off using tenotomy scissors and the renal artery is identified, gently dilated with a hemostat and flushed with 400 mL of heparinized Lactated Ringers (University of Wisconsin solution for export exchanges).

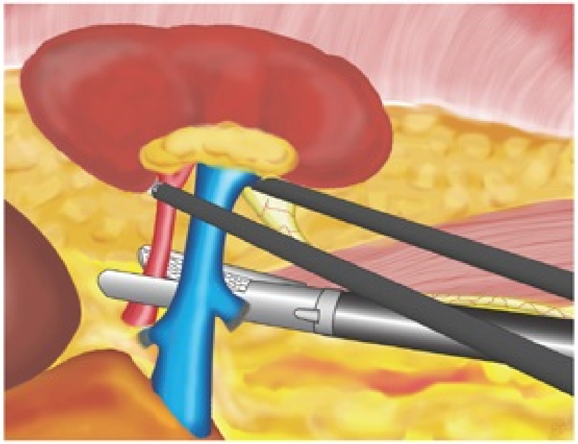

FIGURE 5.7 Elevating the kidney. Using blunt-tip instruments, the kidney is elevated, placing the hilar vessels on stretch to maximize length for transplantation. The assistant holds the camera and upper pole instrument while the surgeon holds the lower pole instrument and operates the stapler.

Closure

A 0-polydioxanone (PDS, Ethicon, Somerville, New Jersey) is used to close the anterior rectus sheath in a running fashion. Insufflation is resumed and inspection of the surgical field for hemostasis is performed, particularly at staple lines and clipped ureteral stump. Prominent pooling of blood after resumption of pneumoperitoneum is concerning. In the absence of any bleeding, the laparoscopic sucker is used to extract as much of the CO_2 as possible prior to trocar removal to lessen the likelihood of postoperative shoulder/chest discomfort due to CO_2 diaphragm irritation. The incisions are infiltrated with 0.5% Marcaine and the ports sites and extraction site incision are closed preferably with 4-0 absorbable monofilament subcuticular stitches.

Routine Postoperative Care

All patients follow a postoperative pathway. The orogastric tube is removed prior to extubation. A recovery room and early postoperative day 1 hematocrit is checked. The Foley catheter is removed and diet advanced to regular early on the first postoperative day and ambulation is encouraged. Intravenous ketorolac is given 0.5 mg/kg prior to extubation and continued around the clock as well as oral opioid pain medications.

Right-Sided Laparoscopic Donor Nephrectomy

Patient preparation, positioning, and acquiring pneumoperitoneum are performed as described earlier. The majority of the steps for a right-sided procedure remain the same as the left except a few notable changes. The orientation of trocars is the same; however, an extra 15-mm trocar is occasionally swapped for the standard 5-mm trocar most caudad later in the procedure for improved staple angle and ultimately renal vein length. The liver sometimes extends caudal and requires a fourth 3-mm trocar placed near the subxiphoid and a locking grasper clamping the abdominal wall below the diaphragm laterally to retract the liver throughout the case. We tend to place this after the colon has been mobilized. The ascending colon tends to travel more medial and the duodenum presents after mobilization rather than the pancreas. The gonadal vein rarely needs to be ligated. The adrenal vein directly enters the vena cava and rarely seen or needed to be ligated. Few, if any, lumbar branches extend from the right renal vein.

Exposure of the retroperitoneum is created by incising the white line of Toldt generally 2 to 3 cm lateral to the ascending colon. This is extended caudal to the pelvic brim and cranial over the kidney, up between the lateral edge of the liver. The liver can be released from lateral attachments and at this point we place the grasping forceps to retract the liver if needed. As the mesentery and colon are swept medial off Gerota fascia using similar techniques described earlier, the duodenum often presents and is gently swept (“kocherized”) medial away from the vena cava and hilum.

The lower pole of the kidney serves as a landmark for locating and identifying the ureter and gonadal vein. The gonadal vein rarely enters the renal vein, and care is taken to trace the anterior surface, incising the Gerota fascia up to the insertion, into the vena cava. Carrying this more cranially often reveals the right renal vein. The ureter typically rests slightly lateral to the gonadal vein at the lower pole. Once identified, it is lifted anteriorly and the lateral and medial attachments released in a manner similar described previously down to the level of the iliac vessels.

The adrenal gland is released from the upper pole of the kidney using LigaSure ligation. A plane is developed between the upper pole and inferior edge of the adrenal gland. This plane is developed down to the posterior quadratus and psoas muscles. Once the upper pole is released, the posterior attachments are released using blunt dissection. The hilar vessels are carefully identified and isolated.

At this point, after coordination with the transplanting surgeon, the extraction site incision is made (as described before) and the most inferior working port switched to a 15-mm trocar to accommodate the endovascular stapler. Often due to the angle of vena cava insertion, using this port site aligns the stapler to maximize renal vein length. The lateral attachments are then divided. Carefully, using a similar “chopsticks” technique as for the left donor nephrectomy, the kidney is elevated placing the hilum on stretch. The renal artery and then vein are stapled and the ureter clipped and cut. The kidney is extracted, and closure is the same as the left side.

OUTCOMES

Results

The initial early technical issues leading to renal allograft dysfunction, failure, and loss in the recipients have largely been overcome. The Cochrane database published a review and meta-analysis of open versus laparoscopic donor nephrectomies in 2011 (10). In summary, laparoscopic approaches were associated with less pain and blood loss but longer warm ischemia times than open procedures; however, no difference in short-term graft consequences. Complication rates were the same. Table 5.2 summarizes the outcome measures in the Cochrane review, none of which had significant differences between the two different surgical approaches.

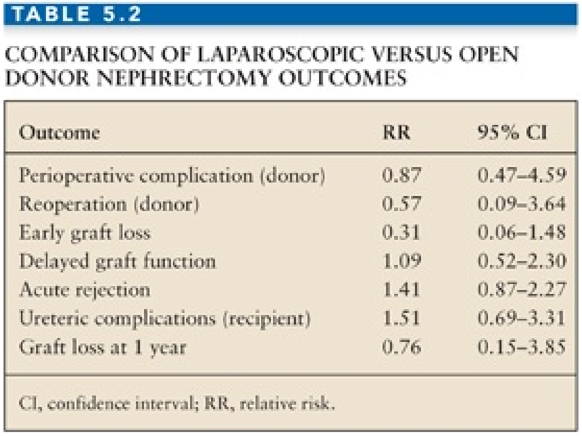
TABLE 5.2

COMPARISON OF LAPAROSCOPIC VERSUS OPEN DONOR NEPHRECTOMY OUTCOMES

Outcome	RR	95% CI
Perioperative complication (donor)	0.87	0.47–4.59
Reoperation (donor)	0.57	0.09–3.64
Early graft loss	0.31	0.06–1.48
Delayed graft function	1.09	0.52–2.30
Acute rejection	1.41	0.87–2.27
Ureteric complications (recipient)	1.51	0.69–3.31
Graft loss at 1 year	0.76	0.15–3.85

CI, confidence interval; RR, relative risk.

Complications

Several studies have published complications rates for donor nephrectomy. Schold et al. (11) reported an overall donor nephrectomy complication rate of 7.9% in the National Inpatient Sample (NIS), analyzing 69,117 cases representing 89% of all donor nephrectomies performed in the United States registered in the SRTR database. However, another NIS study of 6,000 cases demonstrated an 18% complication rate during 1999 to 2005 period (12). Population-based studies are unable to distinguish surgical approaches such as open, hand-assisted laparoscopic, or pure laparoscopic donor nephrectomy. Similarly, there is variation in single-center approaches, methodology, and reporting, with overall complications ranging from 7% to 15% (13–15). Our overall surgical complication rate with more than 1,300 laparoscopic donor nephrectomies is 7.9%. Complications organized by modified Clavien classification are shown in Table 5.3 for our experience (16). Perioperative mortality from donor nephrectomy is very low and reported to be 3.1 per 10,000 donors and considered to be in the range of 0.03% to 0.06% (17).

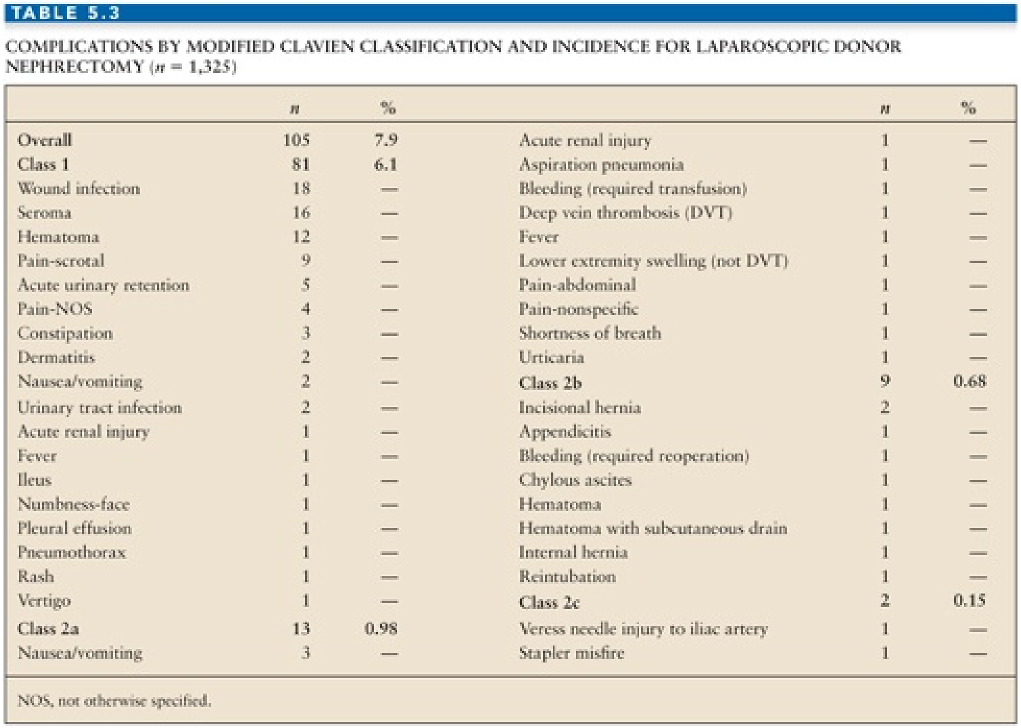

TABLE 5.3

COMPLICATIONS BY MODIFIED CLAVIEN CLASSIFICATION AND INCIDENCE FOR LAPAROSCOPIC DONOR NEPHRECTOMY (n = 1,325)

	n	%		n	%
Overall	105	7.9	Acute renal injury	1	—
Class 1	81	6.1	Aspiration pneumonia	1	—
Wound infection	18	—	Bleeding (required transfusion)	1	—
Seroma	16	—	Deep vein thrombosis (DVT)	1	—
Hematoma	12	—	Fever	1	—
Pain-scrotal	9	—	Lower extremity swelling (not DVT)	1	—
Acute urinary retention	5	—	Pain-abdominal	1	—
Pain-NOS	4	—	Pain-nonspecific	1	—
Constipation	3	—	Shortness of breath	1	—
Dermatitis	2	—	Urticaria	1	—
Nausea/vomiting	2	—	**Class 2b**	9	0.68
Urinary tract infection	2	—	Incisional hernia	2	—
Acute renal injury	1	—	Appendicitis	1	—
Fever	1	—	Bleeding (required reoperation)	1	—
Ileus	1	—	Chylous ascites	1	—
Numbness-face	1	—	Hematoma	1	—
Pleural effusion	1	—	Hematoma with subcutaneous drain	1	—
Pneumothorax	1	—	Internal hernia	1	—
Rash	1	—	Reintubation	1	—
Vertigo	1	—	**Class 2c**	2	0.15
Class 2a	13	0.98	Veress needle injury to iliac artery	1	—
Nausea/vomiting	3	—	Stapler misfire	1	—

NOS, not otherwise specified.

Open conversion rates are generally low and usually around 1%. As with any laparoscopic procedure, there is always the possibility of open conversion. The decision to convert most often reflects good judgment and is not a complication. The surgeon should have all instruments necessary for open surgery. Typically, a subcostal incision connecting two or more ports if possible. In most cases, conversion is due to ongoing hemorrhage or failure to progress secondary to adhesions.

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CHAPTER 6 ■ LAPAROSCOPIC/ROBOTIC NEPHRECTOMY AND PARTIAL NEPHRECTOMY

JEAN-CHRISTOPHE BERNHARD, CHARLES METCALFE, AND INDERBIR S. GILL

Standard transperitoneal and retroperitoneal laparoscopic nephrectomy (LN) were first performed in 1990, and their partial nephrectomy (PN) counterparts followed in 1993 and 1994 (1).

Equivalent 5-year cancer cure rates combined with decreased morbidity and recovery time have made LN the current standard of care for surgically treating renal malignancies in industrialized countries. Laparoscopy is also the standard today for performing nephrectomy for benign disease. Although open partial nephrectomy (OPN) remains the standard of care, pure laparoscopic partial nephrectomy (LPN) has been performed at high-volume medical centers of laparoscopic surgical excellence. However, concerns regarding not only both warm ischemia time and difficulties in technique training but also the large propagation of robotic assistance technology made it progressively replaced by robot-assisted LPN.

DIAGNOSIS

Nowadays, renal masses are most often identified incidentally during radiologic imaging. Only 30% of diagnosed patients present with hematuria or abdominal or flank discomfort. Additionally, patients are increasingly identified incidentally. Tumors are typically characterized and staged using abdominopelvic computerized tomography (CT) or magnetic resonance imaging (MRI) scan and chest radiography. Preoperative blood work includes metabolic panels including serum creatinine, liver function studies, alkaline phosphatase, and calcium. If the latter two studies are elevated or if the patient has bone pain or other evidence of metastases, a bone scan will be performed. Brain imaging is selectively obtained in patients with cerebral symptoms or evidence for metastasis. Nuclear renography is utilized in patients with renal insufficiency or if there is concern regarding the function of the contralateral kidney.

INDICATIONS FOR SURGERY

Simple nephrectomy is indicated for benign conditions such as chronic pyelonephritis, nephrosclerosis, multicystic dysplastic kidney, postrenal transplantation or renovascular hypertension, reflux or obstructive nephropathy, and symptomatic acquired renal cystic or autosomal dominant polycystic kidney disease (ADPKD). Radical nephrectomy is indicated for tumors worrisome for malignancy.

Renal oncologic surgery has evolved concomitantly with stage migration, with a significant shift toward techniques that maximize renal function outcomes in addition to cancer cure. This shift is the result of level II evidence correlating impaired renal function with cardiovascular morbidity and overall mortality (2). Studies have demonstrated superior renal function outcomes and overall survival for patients who undergo PN (or nephron-sparing surgery) rather than radical nephrectomy (3,4). As a result, nephron-sparing surgery is now accepted as standard of care for all stage T1a and most stage T1b renal masses (5). With the ongoing adoption of minimally invasive techniques and robotic assistance spread, surgeons are increasingly performing LPN, which eliminates the morbidity of an open incision. Given the enhanced dexterity and three-dimensional (3D) vision afforded by the robotic platform, a rapidly growing number of PN procedures are being performed robotically (at least in the United States), even for complex and technically “difficult” tumors.

ALTERNATIVE THERAPY

Open radical nephrectomy (ORN) and OPN may be performed. Active surveillance and ablative therapies (such as cryotherapy and radiofrequency ablations) are also therapeutic alternatives, particularly for patients with small renal masses who are elderly or who have significant medical comorbidities, hereditary forms of renal cancer, or multiple tumors. Ablative procedures can be performed percutaneously with CT or MRI guidance and laparoscopically.

PATIENT PREPARATION

A formal bowel preparation is not routinely performed, but a clear liquid diet the day before surgery augmented by a Dulcolax suppository or an oral saline cathartic (e.g., magnesium citrate or Fleet Phospho-Soda) is often employed. One gram of cefazolin is administered preoperatively. Deep venous thrombosis prevention with subcutaneous heparin (5,000 U 2 hours prior to procedure and continued every 12 hours postoperatively until the patient is ambulatory or up to 1 month postoperative in case of neoplastic disease) and/or pneumatic compressive stockings are used.

PATIENT POSITIONING

Under general anesthesia, intravenous access and endotracheal intubation are obtained with the patient supine. Orogastric and Foley catheters are inserted to decompress the stomach and bladder. The patient is then placed in a modified (30- to 70-degree) lateral decubitus position, with the umbilicus over the break in the table. For retroperitoneoscopic procedures, the patient is placed in or closer to the true lateral decubitus position. An axillary roll is placed, the table is flexed as necessary (usually minimally compared with open flank surgery), and a beanbag or padding is positioned to support the buttocks and flank. Pillows are placed between the flexed lower and straight upper leg. The upper arm rests on a well-padded arm board (or pillows) without tension on the brachial plexus. Three-inch tape is used to secure the patient around the hips, shoulders, and thighs to ensure stability when rolling the table to facilitate bowel retraction (Fig. 6.1).

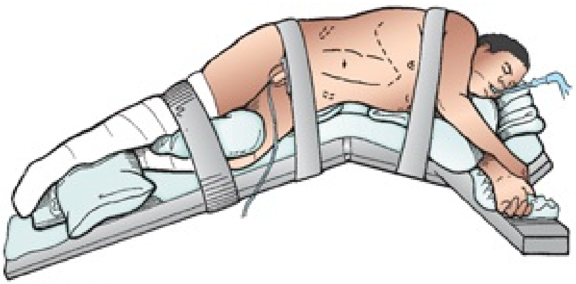

FIGURE 6.1 The patient is placed in a modified (70-degree) lateral decubitus position, with the umbilicus over the break in the table. (Reprinted with permission from Bishoff JT, Kavoussi LR, eds. *Atlas of Laparoscopic Retroperitoneal Surgery*. Philadelphia: WB Saunders, 2000. Copyright © 2000 Elsevier Inc. All rights reserved.)

SURGICAL TECHNIQUE

Transperitoneal Radical or Total Nephrectomy

Access

Although the insufflation technique with the Veress needle can be used, we recommend an open access for the camera port placement. It is commonly inserted at the level of the umbilicus lateral to the ipsilateral rectus muscle. The abdomen is insufflated to 13 to 15 mm Hg. Some surgeons prefer a pressure of 20 mm Hg during the trocar placement. Typically, a 10- or 12-mm trocar is placed lateral to the rectus at the level of the umbilicus using a visual obturator trocar (e.g., Visiport, AutoSuture or Optiview, Ethicon Endo-Surgery). Once the peritoneum has been entered, the intraperitoneal contents are inspected for injury or adhesions. Trocar site placement varies significantly based on surgeon preference and patient body habitus. Most surgeons prefer the laparoscope (“camera”) port positioned between the working ports, which is the authors’ preference. Some place it caudad to the working ports. Many surgeons use a 30-degree laparoscope placed through an umbilical port, with working ports widely spaced in the subxiphoid midline and the far lateral abdomen (anterior axillary line, umbilical level), creating a 90-degree angle in relation to the umbilical trocar. Other surgeons place the working ports closer to the umbilical trocar, keeping them at least 10 cm apart. Others reduce the angle of the working ports in relation to the umbilicus to approximately 60 to 70 degrees, creating a trocar “diamond” configuration. Alternatively, one can use a 0-degree laparoscope placed through a trocar lateral to the rectus muscle and just cephalad to the umbilicus, with the working ports shifted slightly cephalad and laterally, respectively, to maintain at least 10-cm or five-fingerbreadths distance between trocars. A 5-mm trocar is often placed in the far lateral (anterior to posterior axillary line) position for retraction, and another 5-mm trocar is often placed below the xiphoid process for right-sided procedures to elevate the liver using a locking grasper attached to the lateral abdominal wall. Obese patients or patients with protuberant abdomens will need to have the trocars shifted laterally to maintain effective working angles into the retroperitoneum. Although technically more challenging, single-portal access nephrectomy can be performed for small hypotrophic kidney.

Reflection of the Colon

The ipsilateral ascending or descending colon must be mobilized to gain access to the kidney and renal hilum. The parietal peritoneum is first incised medial to the line of Toldt, approximately 1 cm lateral to the mesenteric fat lying lateral to the colon. This incision is carried from the iliac vessels to the level of the spleen (left) or liver (right). Atraumatic graspers are used in the nondominant hand to provide counter tension, and a hook electrode, Endoshears (scissors), or harmonic scalpel is used in the dominant hand to perform the dissection. Endoshears are particularly useful when dissecting in close proximity to bowel and when tissue planes are relatively avascular. Selective use of monopolar cautery through the instrument or use of a bipolar grasper in the nondominant hand allows for an efficient and elegant dissection by an experienced surgeon. Conversely, the harmonic scalpel excels at maintaining hemostasis when tissue planes are more vascular, and it is an excellent blunt-tipped dissection tool. Less experienced surgeons and surgeons in training may find the harmonic scalpel an easier tool to master. For left-sided procedures, many surgeons advocate carrying the peritoneal incision above the spleen laterally, allowing the spleen to fall medially with the pancreas and colon. Others prefer to carry the peritoneal incision through the phrenicocolic ligament to the spleen but then carry the dissection medially, leaving the spleen suspended on a “hammock of peritoneum caudad to the spleen and extending to the left abdominal sidewall” (Fig. 6.2). The splenophrenic attachments are left intact while the splenocolic and then renocolic fascial attachments are divided in layers until the descending colon is fully mobilized medially and the left gonadal vein is visible.

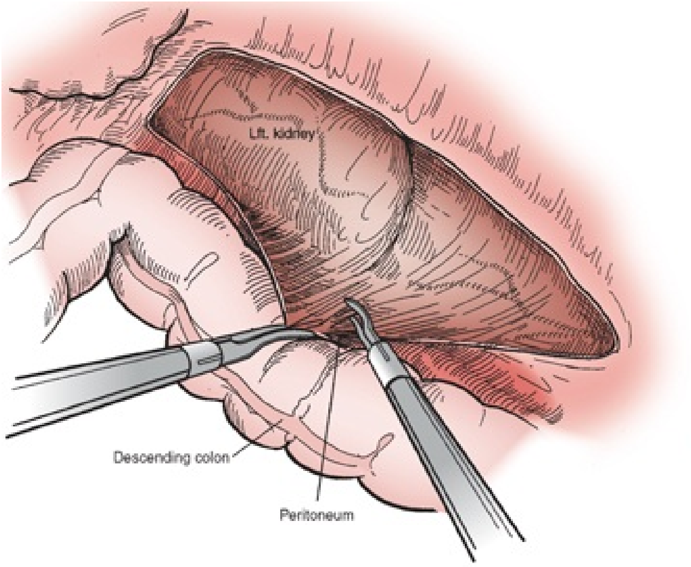

FIGURE 6.2 Mobilization of the colon using medial traction to demonstrate and divide attachments. (Reprinted with permission from Bishoff JT, Kavoussi LR, eds. *Atlas of Laparoscopic Retroperitoneal Surgery*. Philadelphia: WB Saunders, 2000. Copyright © 2000 Elsevier Inc. All rights reserved.)

For right-sided procedures, the peritoneum just lateral to the ascending colon is divided and carried to the level of the liver. This peritoneal incision is also carried medially, staying approximately 1 cm away from the lateral border of the colonic hepatic flexure. This incision then proceeds cephalad to approximately 1 cm below the liver and back laterally along the inferior surface of the liver to the sidewall. This approach will leave a wedge-shaped area of peritoneum covering the anterior aspect of the right kidney (Fig. 6.3). Once the ascending colon is mobilized medially, the duodenum is subsequently identified and a fascial incision is made approximately 1 cm lateral to its second stage. A Kocher maneuver is performed to move the duodenum medially. Third, the inferior vena cava (IVC) is exposed by incising the fascia and dissecting along its lateral border. For both left- and right-sided procedures, care is taken to preserve the lateral attachments of the kidney to prevent it from falling medially, inhibiting dissection of the renal hilum and the medial aspect of the Gerota fascia.

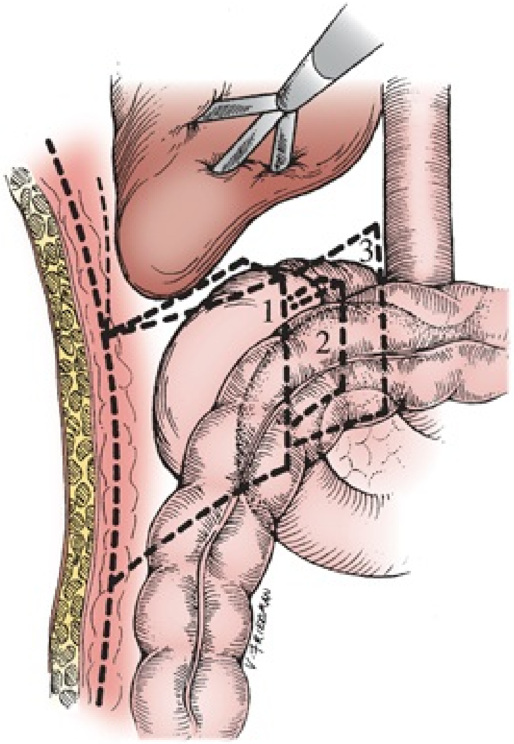

FIGURE 6.3 Diagram of the right-sided nephrectomy demonstrating the wedge-shaped configuration. The numbers refer to the three distinct levels of dissection along the medial aspect of the kidney: colon, duodenum, and inferior vena cava.

Gonadal Vein Dissection

Once the colon is fully mobilized, the gonadal vein is identified. Many urologists find the gonadal vein to be the “gateway” for initiating the nephrectomy portion of the procedure and carrying the dissection to the renal hilum. For left-sided nephrectomies, the fascia overlying the gonadal vein is divided and this dissection is carried cephalad to the renal vein. Care must be taken to dissect anterior to the gonadal vein to prevent injuring small gonadal venous tributaries or hilar vessels. The harmonic scalpel is useful for dividing these fascial attachments and maintaining hemostasis. This will allow for exposure of the anterior aspect of the left renal vein and subsequently the adrenal vein. The adrenal vein may be dissected using the harmonic scalpel or a gently curved dissector (e.g., Maryland). It is subsequently cauterized (e.g., with a paddle bipolar instrument), clipped (e.g., with Hem-O-Lok clips), and divided. The gonadal vein is then divided 1 to 2 cm below the renal vein in a similar fashion. It is included with the radical nephrectomy specimen, particularly for large and lower pole tumors. For right-sided procedures, the fascia over the gonadal vein may similarly be divided along the course of the vein up to its junction with the IVC. The right gonadal vein may, particularly for large tumors, be divided and removed with the specimen. Conversely, the dissection can be made just lateral to the right gonadal vein for smaller mid and upper pole tumors. The plane of dissection between the gonadal vein and the tail of the Gerota fascia (containing the ureter) is developed, and the latter is elevated anterolaterally by the assistant (using a laparoscopic Kittner, atraumatic grasper, or suction device) to allow dissection to the renal hilum via an inferoanterior approach (Fig. 6.4A and B).

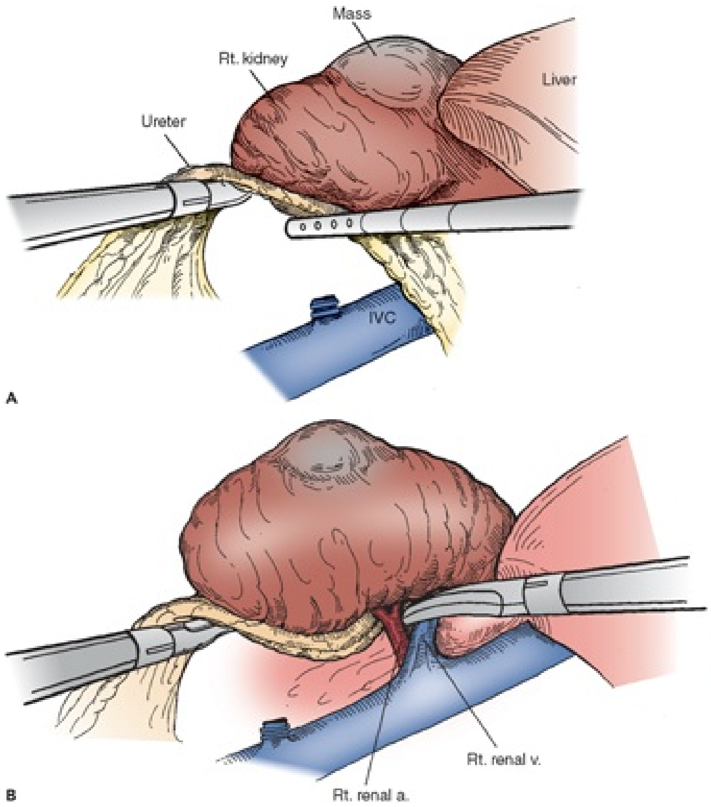

FIGURE 6.4 Elevation of ureter and tail of the Gerota fascia (**A**) to allow dissection to and exposure of renal vessels (**B**). *IVC*, inferior vena cava. (Reprinted with permission from Bishoff JT, Kavoussi LR, eds. *Atlas of Laparoscopic Retroperitoneal Surgery*. Philadelphia: WB Saunders, 2000. Copyright © 2000 Elsevier Inc. All rights reserved.)

Dissection of Ureter and Tail of the Gerota Fascia

For right-sided procedures, the ureter and tail of the Gerota fascia are elevated anterolaterally and the dissection carried along the gonadal vein to the IVC cephalad and to the iliac vessels caudad. For left nephrectomies, the dissection of the ureter and medial tail of the Gerota fascia is often performed after dividing the left adrenal and gonadal veins, if a true radical nephrectomy is to be performed. The adrenal gland and gonadal vein are spared when performing a simple nephrectomy or in select cancer patients without evidence of invasion on preoperative imaging. The tail of the Gerota fascia is mobilized medial to the gonadal vein from the renal hilum to the iliac vessels.

Securing the Renal Blood Vessels

Firm anterolateral elevation of the lower pole is critical in order to facilitate dissection of the hilum. This is accomplished by placing a laparoscopic Kittner or atraumatic grasping instrument under the tail of the Gerota fascia, the ureter, and the lower pole and lifting to the abdominal sidewall. With the hilum on tension, a harmonic scalpel, suction instrument, hook electrode, dissector (e.g., Maryland), or Endoshears can be used to dissect out the renal artery and vein and any necessary tributaries (e.g., lumbar or accessory vessels). Lymphatic vessels and fascial attachments inferior to and occasionally encasing the renal artery must be divided bluntly or sharply. Once adequate vessel exposure (at least a 2-cm space) is created, an endovascular gastrointestinal anastomosis (GIA) stapler is used to divide first the renal artery and then the vein. Alternatively, a series of at least three Hem-O-Lok clips may be applied to the vessels, dividing them approximately 1 cm lateral to the clips. Hilar side branches (gonadal, adrenal, lumbar, and accessory) may be ligated and divided in a variety of ways. Cauterization with either the LigaSure device or three overlapping deployments of a standard paddle bipolar cautery is effective. Standard titanium or locking polymer Hem-O-Lok clips may be used. The authors favor sequential paddle bipolar cauterization of the vessel and placement of a Hem-O-Lok clip on the stay side of the vessel if it will not be in the path of the endovascular GIA stapler when dividing the renal vessels.

Upper Pole Isolation

Once all hilar vessels have been divided, the dissection is carried superiorly. For right radical nephrectomies (RNs), the adrenal vein must be identified, ligated, and divided. Hem-O-Lok clips, preferably two on the stay side, may be used. The remaining suprarenal attachments and middle suprarenal arteries are divided with the harmonic scalpel or stapler (Fig. 6.5). A similar dissection can be performed for left RNs, separating the adrenal from the aorta and diaphragm. Alternatively, for simple nephrectomies and selectively for small, non–upper pole renal tumors with a normal ipsilateral adrenal gland on preoperative abdominal CT or MRI and intraoperative exam, the adrenal gland can be spared by placing the kidney on caudad traction and dividing the attachments between the adrenal gland and upper pole, staying adjacent to the adrenal. At this point, if it has not been performed previously, the ureter is clipped and divided and any remaining posterior or lateral attachments are divided by rotating the kidney as necessary.

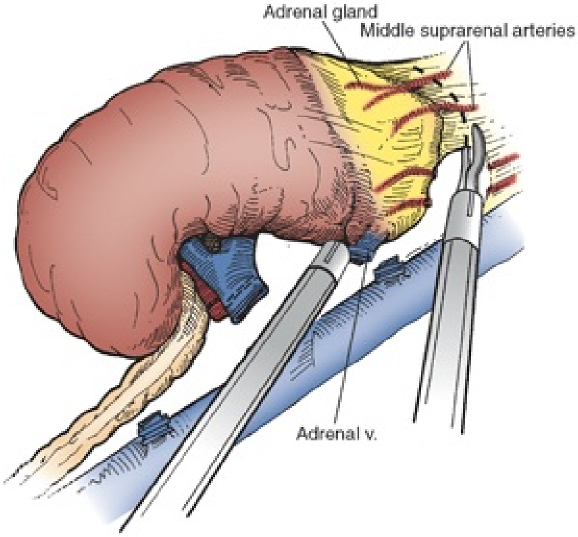

FIGURE 6.5 Adrenal gland excision with a right radical nephrectomy specimen. (Reprinted with permission from Bishoff JT, Kavoussi LR, eds. *Atlas of Laparoscopic Retroperitoneal Surgery*. Philadelphia: WB Saunders, 2000. Copyright © 2000 Elsevier Inc. All rights reserved.)

Organ Entrapment

Benign kidneys may be morcellated in a durable entrapment sac, but malignant kidneys should be removed intact. The risk for tumor spillage and the loss of histologic staging information virtually always outweigh the morbidity benefits of minimizing the extraction incision. The kidney is placed into a deployable entrapment sack (e.g., Endo Catch II, U.S. Surgical, Norwalk, Connecticut). Hemostasis is checked, and then the sack is brought out through an incision extended from a 12-mm trocar site. Alternatively, the specimen may be removed through a Pfannenstiel incision. Trocar sites larger than 5 mm should have a fascial closure suture (e.g., interrupted 0 Vicryl) placed prior to specimen extraction.

Retroperitoneal Nephrectomy

Access

A 2-cm incision is made just below the tip of the 12th rib in the midaxillary line. A Kelly clamp is used to separate the subcutaneous fat and expose the flank musculature. The muscle is bluntly divided, and the underlying thoracolumbar fascia is pierced to enter the pararenal fat of the retroperitoneum. “S” type or Army-Navy retractors are used for exposure, and a fingertip is inserted and rotated 360 degrees in order to palpate the psoas muscle and confirm an appropriate retroperitoneal location. A balloon dilator is introduced and filled to 800 mL with room air. During insufflation, a 10-mm laparoscope may be introduced to view the dissection. A 10-mm blunt-tipped cannula is introduced with 30 mL of air in the balloon (U.S. Surgical). After tightening the outer ring sponge to compress the balloon against the inner abdominal wall, the retroperitoneum is insufflated to 15 to 20 mm Hg. Of note, some surgeons alternatively make the incision midway between the iliac crest and the tip of the 12th rib in the posterior axillary line. Additionally, a visual obturator trocar with a 10-mm 0-degree laparoscope may be used instead to enter the retroperitoneal space. Entry must be at a 10-degree anterior angle. Angling too far posteriorly will injure the quadratus or psoas musculature, whereas too anterior of a trajectory may allow entry into the peritoneum or cause colon injury.

Procedure

After obtaining retroperitoneal entry, blunt dissection is performed using only the scope. Anteriorly, the peritoneum is swept medially, exposing the transversalis fascia. Once peritoneal dissection off the abdominal wall is complete, accessory ports are placed in the upper and lower midaxillary line and a 5-mm trocar is placed in the anterior axillary line (Fig. 6.6). Some surgeons eliminate the lower midaxillary line port (three-port approach), while others maintain this trocar and add another anterior to it (five-port approach).

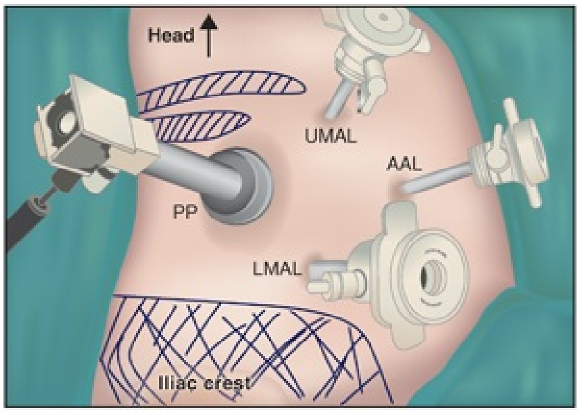

FIGURE 6.6 Port placement during retroperitoneal right retroperitoneoscopic renal surgery. The primary port (*PP*) is inserted by the open technique caudad to the tip of the 12th rib. The 12-mm lower midaxillary line (*LMAL*) port is placed 2 to 3 cm cephalad to the iliac crest. The 5-mm anterior axillary line (*AAL*) port is placed at the level of the PP. The 5-mm upper midaxillary line (*UMAL*) is placed near the tip of the 11th rib. Care must be taken to avoid transpleural placement of this trocar.

If balloon dilation was effective, the kidney should be displaced anteriorly. The psoas muscle is cleaned of fat and the dissection is carried cephalad and medially until the pulsating renal artery is visualized. The Gerota fascia is incised and the renal hilum is dissected, clipping the artery and the vein. For left-sided nephrectomy, the posterior ascending lumbar vein may be encountered prior to viewing the artery. It should be dissected, clipped with Hem-O-Lok clips, or cauterized and divided. Circumferential dissection of the Gerota fascia is performed. On the right side, cephalad dissection will lead to the adrenal vein, which will be clipped or cauterized and divided. The adrenal vein will also typically be divided during left nephrectomy. The ureter is doubly clipped and divided, followed by division of the remaining retroperitoneal attachments. The specimen is entrapped in a deployable sack and removed through the initial port site by extending the incision horizontally anterior to the tip of the 12th rib. Morcellation of benign kidneys can be performed in an impermeable sack (e.g., LapSac, Cook Urologic, Spencer, Indiana).

The peritoneal cavity may be entered during anterior dissection of the Gerota fascia, but it does not necessitate conversion to a transperitoneal technique. Conversion to a transperitoneal laparoscopic or open flank nephrectomy approach can be performed in difficult cases. Similar to the transperitoneal technique, the retroperitoneum is inspected for hemostasis with CO_2 pressure at 3 to 4 mm Hg prior at end of the case. The port sites will not require fascial closure but are irrigated, and the skin is closed with 4-0 subcuticular suture.

Transperitoneal Partial Nephrectomy

Access and renal exposure are similar to transperitoneal LN (Fig. 6.7A and B). The renal hilum is identified (Fig. 6.8). At this point, the operation will vary somewhat, depending on the PN technique that is employed. In most instances, the renal artery and vein are carefully dissected, and elastic loops are placed for safe recognition of the arteries (Fig. 6.9A and B). A complete hilum dissection can be performed if superselective clamping/zero-ischemia PN is planned, and direct tumor feeding arteries can be divided (Fig. 6.10A–D). The Gerota fascia is then opened horizontally across the anterior midpole, and the perirenal fat is reflected off the capsule. Fat is reflected until the tumor is visualized and then exposed, leaving it covered with fat. Endoshears or the harmonic scalpel is used to separate the fat from the capsule, with care taken not to get subcapsular (Fig. 6.11). Intraoperative ultrasound is performed in case of totally endophytic tumor or to assess the depth of the tumor (Fig. 6.12). Complete liberation of the kidney is important to ensure to get the best tumor exposure and visualization of all its faces (Fig. 6.13A and B).

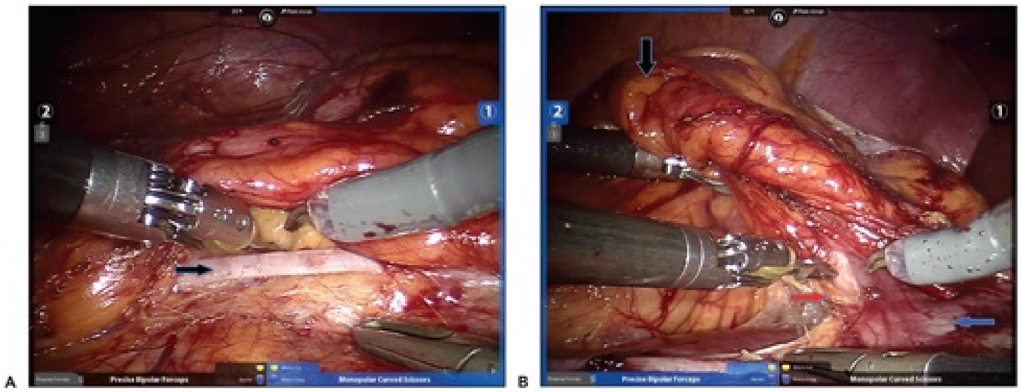

FIGURE 6.7 A: Dissection along the gonadal vein (*arrow*) during a right robotic PN carried cephalad to the lateral side of the vena cava. B: The lower pole of the kidney along with its fat (*black arrow*) is then elevated anterolaterally by the third robotic arm (using a ProGrasp forceps) to allow dissection to the renal pedicle (*red arrow*) via an inferoanterior approach. The IVC is displayed at the tip of the *blue arrow*.

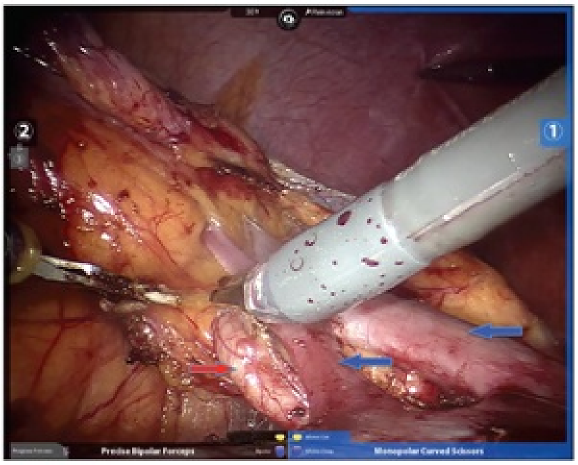

FIGURE 6.8 Pedicle dissection (in this case, two renal veins [*blue arrows*] and an early retrocaval division of the artery [*red arrow*]).

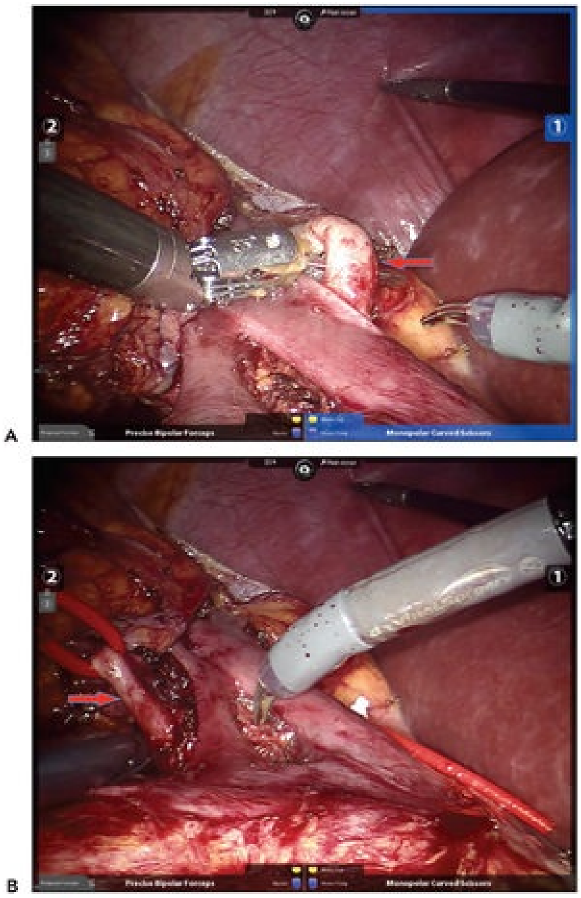

FIGURE 6.9 **A:** The secondary superior artery (*red arrow*) is first isolated and an elastic loop will be placed. **B:** The secondary lower artery (*red arrow*) is also isolated and spotted with an elastic loop.

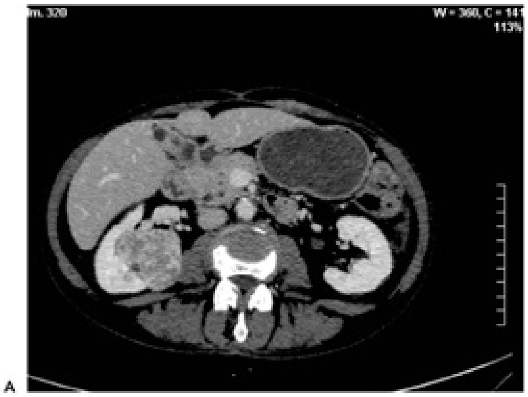

FIGURE 6.10 Due to the characteristics of the tumor (5.4 cm, right upper pole, hilar tumor) shown on the axial CT scan slice (**A**), *(continued)*

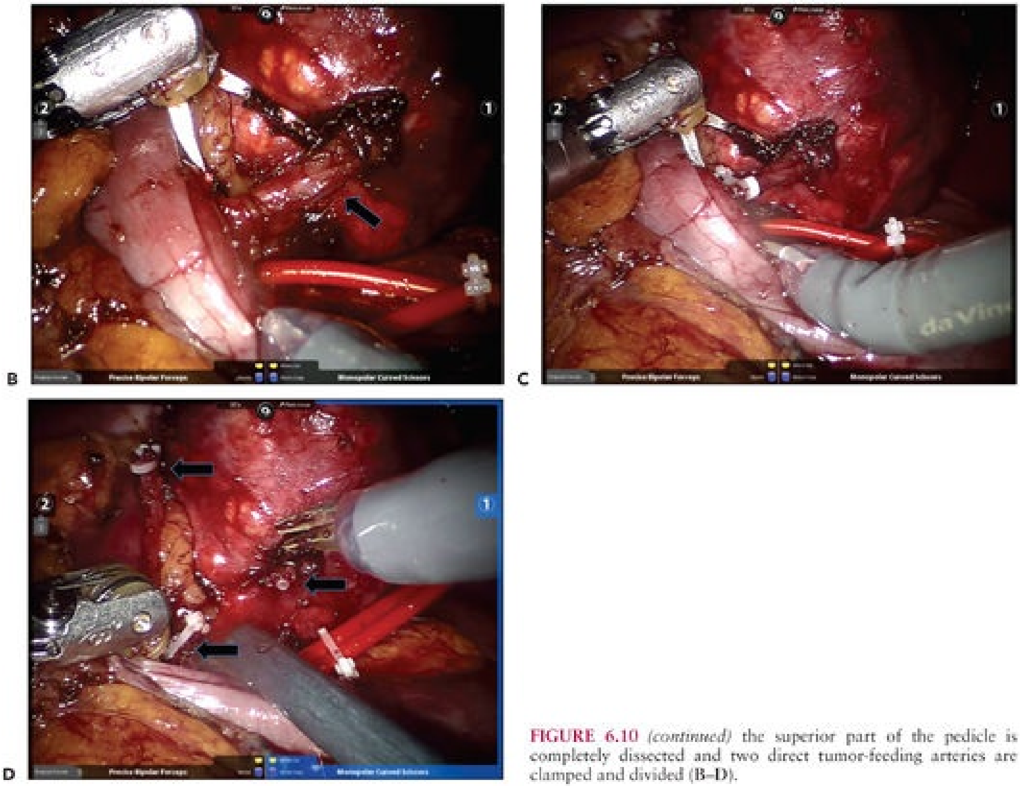

FIGURE 6.10 *(continued)* the superior part of the pedicle is completely dissected and two direct tumor-feeding arteries are clamped and divided (**B–D**).

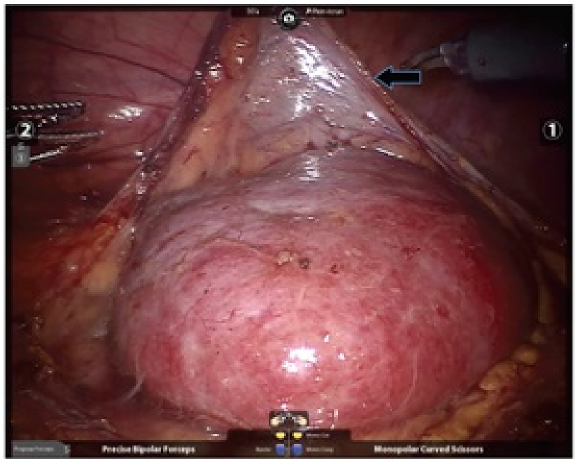

FIGURE 6.11 The Gerota fascia (*arrow*) is elevated anterolaterally by the assistant or by the third robotic arm (ProGrasp forceps). The anterior face of the kidney (view of the lower pole) is progressively freed of fat.

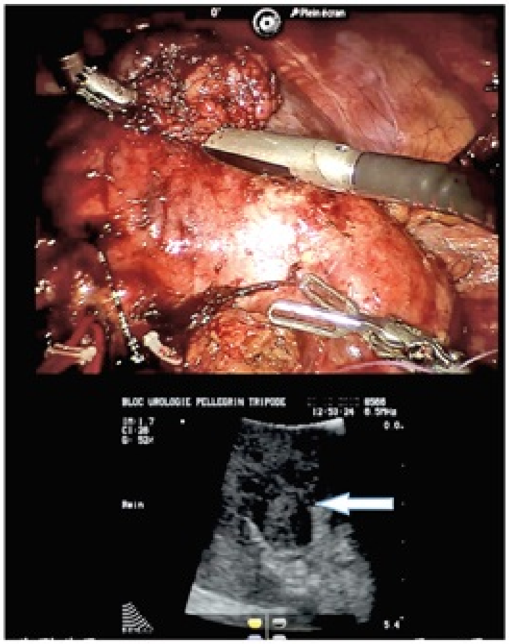

FIGURE 6.12 Intraoperative ultrasound with TilePro display for a hypoechoic, totally endophytic renal mass (*arrow*).

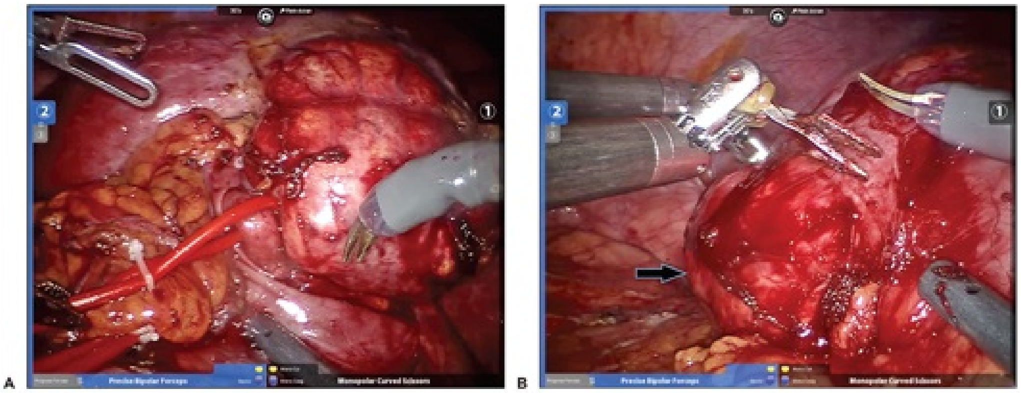

FIGURE 6.13 **A:** Anterior view of the upper pole hilar tumor. **B:** The kidney is then completely rotated on its pedicle to display the posterior face of the tumor (*arrow*).

The major challenges of laparoscopic nephron-sparing surgery are difficulty performing regional hypothermia (cold ischemia), difficulty maintaining hemostasis if hilar clamping is avoided, and difficulty completing the procedure within a 20-minute warm ischemic period. Previously, numerous techniques were used in an effort to perform simultaneous tumor resection and hemostasis but are not recommended, and LPN technique may closely mimic the OPN technique. Before vessel clamping and incision, tumor circumference is marked by scoring the renal capsule with electrocautery using monopolar scissors. Intraoperative ultrasound is used to delineate tumor margins, if necessary. Both the renal artery and vein can be clamped with laparoscopic bulldog clamps, but usually arterial clamping only is enough (Fig. 6.14). Small polar or very exophytic tumors can be removed without clamping (zero-ischemia). Based on tumor location and preoperative careful CT scan analysis (potentially with vascular 3D imaging reconstructions), a superselective arterial clamping can be decided in order to avoid ischemic injury to safe parenchyma regions. The excision is initiated by dissecting perpendicularly into the kidney with monopolar curved laparoscopic scissors (Fig. 6.15). This approach causes less tissue distortion than the use of the harmonic scalpel, bipolar cautery, or “hot scissors” (which are ineffective at preventing bleeding or urine leakage) and allows for a more accurate inspection for a positive surgical margin or an opening into the collecting system. A meticulous effort is made to avoid dissecting too superficially into the pseudocapsule or the tumor itself. The tumor is removed with the thinnest margin of normal parenchyma because tumor enucleation is as safe as real tumorectomy. Visual assessment of negative margin is performed during tumor excision as well as collecting system opening (Fig. 6.16A and B). Absorbable suture (4-0 Monocryl or V-Loc barbed suture) is used in a running fashion to close the collecting system if entered and perform parenchymal hemostasis at the same time, of which can be anchored by Hem-O-Lok or tied (Fig. 6.17). An interrupted sutured closure of the capsule or running crossing sutures with Hem-O-Lok, often bolstered, is then performed over a Surgicel or Gelfoam sponge (Fig. 6.18). The closure is often augmented by hemostatic agents (e.g., Tisseel or FloSeal) placed directly into the defect or impregnated in the Gelfoam. A roll of Surgicel may also be placed into the defect prior to reapproximating the capsule.

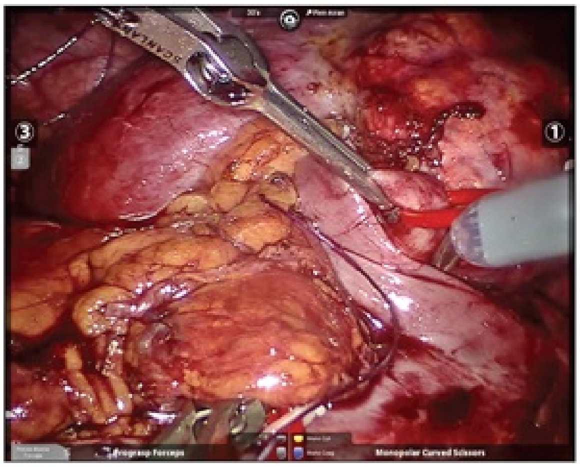

FIGURE 6.14 The superior secondary artery is clamped with a laparoscopic bulldog.

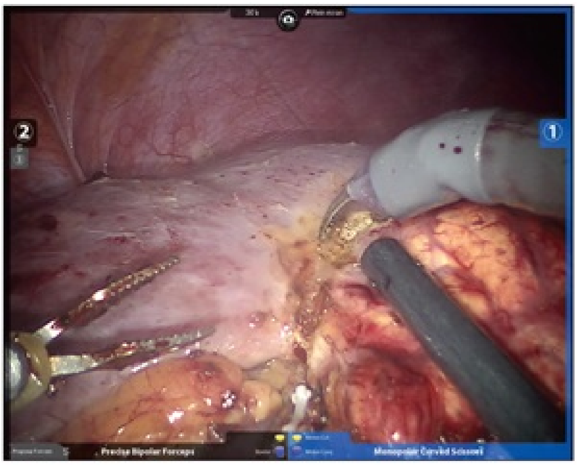

FIGURE 6.15 The excision of the tumor is initiated by dissecting perpendicularly into the kidney with the monopolar curved scissors.

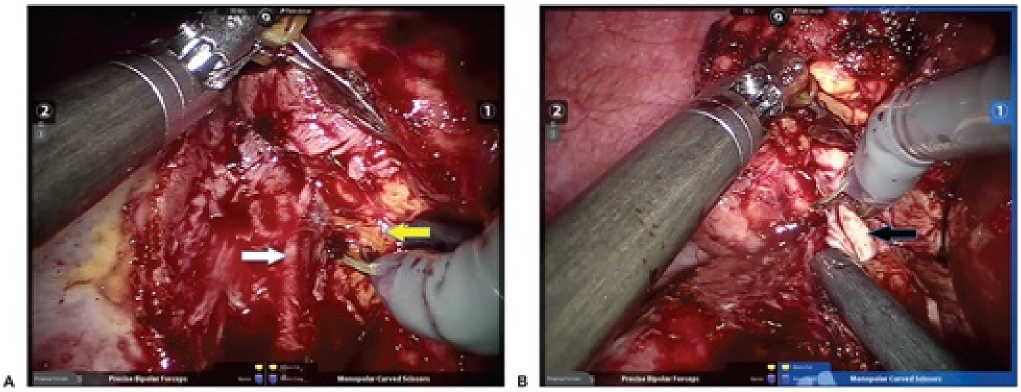

FIGURE 6.16 **A:** The tumor excision is carried on with cold scissors along an arterial branch (*white arrow*) and entering the sinusal fat (*yellow arrow*). **B:** Large opening of the collecting system (*black arrow*).

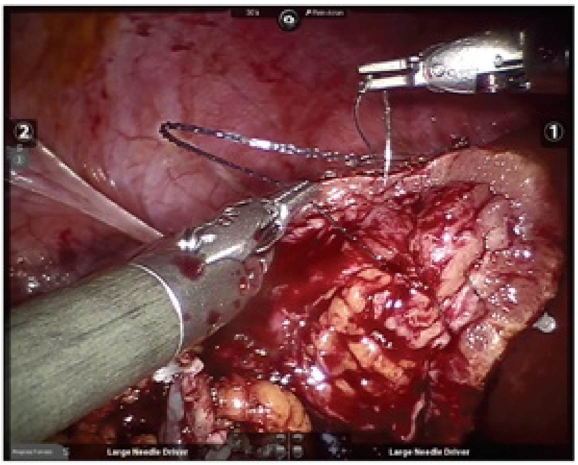

FIGURE 6.17 V-Loc barbed running suture for collecting system closure and parenchymal hemostasis.

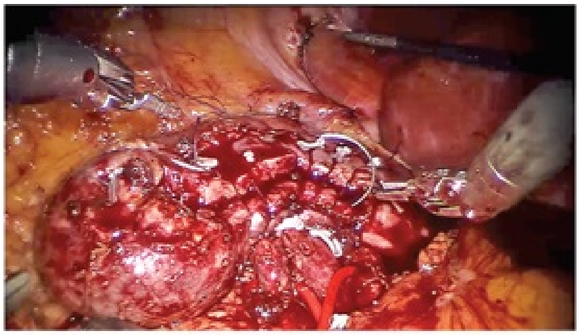

FIGURE 6.18 Capsular renorrhaphy: running crossing suture with Hem-O-Lok reapproximating the edges of the parenchymal wound.

The bulldog clamps are released and hemostasis assessed. In order to decrease warm ischemia time, unclamping can be performed just before superficial renorrhaphy (6). The retroperitoneum is irrigated and aspirated. If hemostasis is adequate at an insufflation pressure of <5 mm Hg, then the perinephric fat is reapproximated. It may be sutured or held in position with clips (Fig. 6.19). A closed system drain (e.g., Jackson-Pratt) is placed inside of the Gerota fascia and away from the renal parenchymal closure. The specimen is placed in a deployable entrapment sack if not done previously and extracted. The specimen inspection allows confirming the macroscopic negative margin status (Fig. 6.20). The incisions are closed.

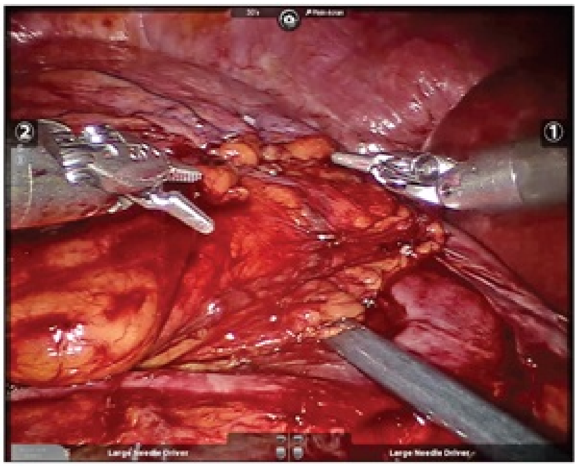

FIGURE 6.19 Reapproximation of the perinephric fat and closure of the Gerota fascia with an absorbable running suture ensured with Hem-O-Lok.

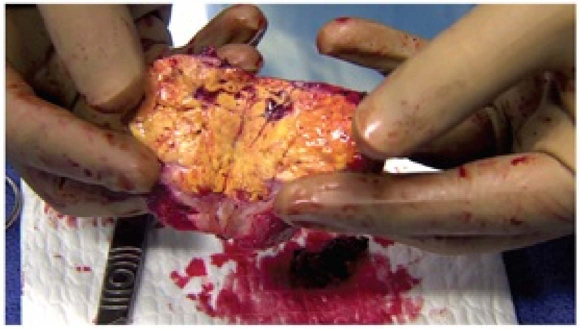

FIGURE 6.20 Specimen macroscopic inspection after opening.

Transperitoneal Robotic Partial Nephrectomy

Patient positioning is similar to laparoscopic. Peritoneal access is gained. The 12-mm port (camera port) is placed in line with the tip of the 12th rib and along the lateral rectus line. The peritoneum is inspected for further port placement. The 8-mm robotic ports are then placed. A bariatric robotic port is placed at the costal margin one handbreadth lateral and cephalad to the camera port. A second 8-mm bariatric port is placed along the same line as the camera but just cephalad to the pubic bone. In order to use the robotic technology to its fullest potential, a third regular 8-mm robotic port is placed laterally directly above the lower pole of the kidney (used to help retract). An equilateral triangle configuration is formed between the camera port, the lateral robotic port, and the lower robotic port to minimize instrument clashing. Assistant ports are placed between the camera port and the lower robotic port as well as one between the camera port and the upper robotic port. As in regular laparoscopic surgery, a liver retractor port is placed for right-sided tumors (Fig. 6.21).

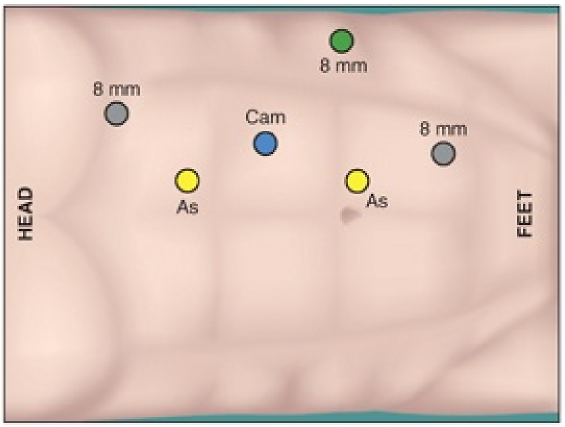

FIGURE 6.21 Port placement for a left robotic transperitoneal PN. The 12-mm endoscope port is *blue*, and 8-mm ports are used for left, right, and fourth arms. *As* are the assistant ports.

The robot is docked posteriorly to the patient with the camera arm coming in to the patient on a 15-degree angle in line with the camera port (Fig. 6.22).

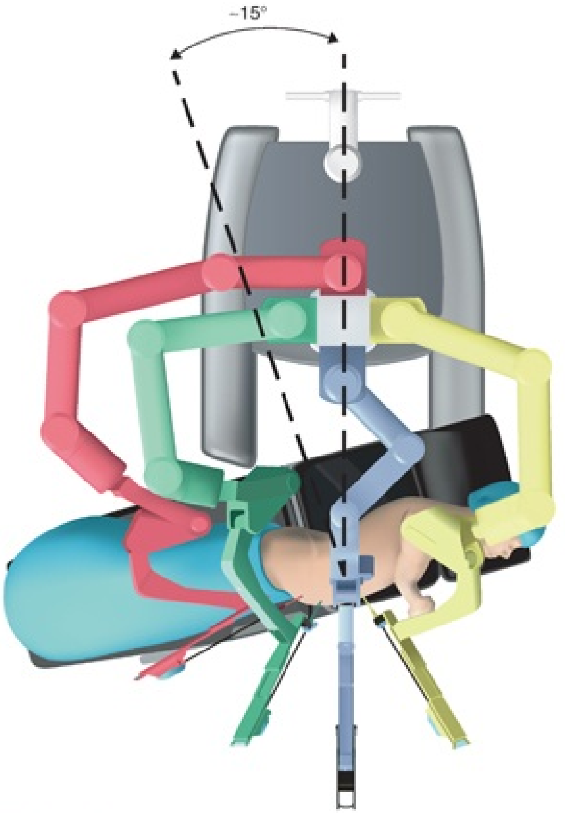

FIGURE 6.22 Top view of robot docking position for a right robotic transperitoneal PN.

Tumor resection and renorrhaphy principles are similar to laparoscopic methods. The advantages to the robotic technology are the 7 degrees of freedom and 90 degrees of articulation made possible by the EndoWrist. This allows for more intricate pedicle and tumor dissection as well as renorrhaphy. Robotic assistance greatly facilitates the complete hilum dissection required for superselective clamping/zero-ischemia techniques.

Retroperitoneoscopic Partial Nephrectomy

Access and renal exposure are as described in the description of retroperitoneoscopic nephrectomy. This technique is typically performed only by true LPN experts when treating small posterior renal tumors. Hilar dissection and clamping are performed selectively. Excision of the tumor is performed as described for transperitoneal LPN with negative margins confirmed and the defect covered with a fibrin glue bandage if shallow (cortex) or closed with interrupted capsular/parenchymal sutures if deeper (e.g., into the renal medulla). Of note, the limited space within the retroperitoneum makes suturing difficult, and most laparoscopic surgeons prefer to perform LPN transperitoneally. The specimen is entrapped in a deployable sack and removed, followed by hemostasis confirmation, drain placement, and closure.

Retroperitoneal Robotic Partial Nephrectomy

The patient is placed in the full flank position. Full flex is performed in order to try to achieve the maximal distance between the iliac crest and the 12th rib. The camera port is placed in the midaxillary line two fingerbreadths cephalad of the iliac crest. Access into the retroperitoneum is the same as with laparoscopic. The 8-mm robotic ports are placed under direct vision with a 30-degree up camera. The first two robotic ports are placed in the posterior and anterior axillary line. The peritoneum is then swept medially, and the fourth robotic port is placed as medial and inferiorly as possible under direct vision. An assistant port is placed between the camera port and the medial dissecting port (Fig. 6.23).

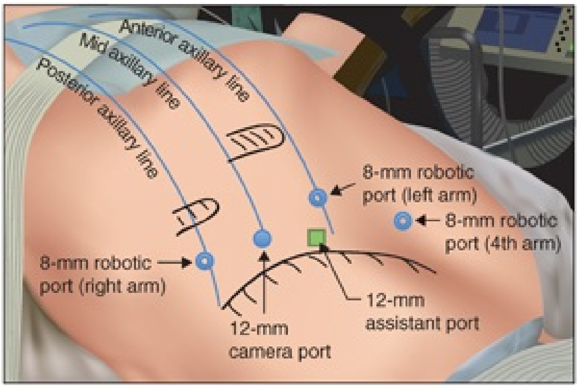

FIGURE 6.23 Port placement for a right robotic retroperitoneal PN.

The robot is docked at the head of the patient. The steps of the retroperitoneal portion of the case are similar to the laparoscopic description.

POSTOPERATIVE CARE

Postoperative care is similar regardless of the laparoscopic approach, and it is similar for nephrectomy and PN patients. Ketorolac (Toradol) 15 mg every 6 hours as requested is typically prescribed for 36 hours. Oral narcotics are made available if necessary. A clear liquid diet is resumed immediately and advanced as tolerated. The patient ambulates on postoperative day 1 and is typically discharged in the evening or the following morning. Parenteral antibiotics are discontinued on postoperative day 1. Oral analgesics are prescribed on discharge. Dulcolax suppositories are given as necessary for postoperative constipation, and patients can be discharged taking a stool softener (e.g., Colace). The drain is usually removed at postoperative day 2 when the volume has decreased to <50 mL per day. For PN, if a question exists regarding a urinary leak, a drain fluid creatinine level is obtained.

OUTCOMES

Laparoscopic Nephrectomy

In order for laparoscopic radical nephrectomy (LRN) to replace ORN as the standard of care, it has to provide equal cancer control with improved patient morbidity and convalescence at comparable operative efficiency. All three issues have been well demonstrated, and it has been confirmed that the oncologic efficacy of LRN for the treatment of localized renal cell carcinoma is equivalent to that of ORN (7–12).

In 2007 already, Colombo et al. (11) reported a 5-year 81% overall and a 90% cancer-specific survival for their LRN cohort compared to a 6-year 79% overall and 92% cancer-specific survival for their ORN cohort. The mean tumor size was 6 cm (5.8 and 6.2 cm, $P = .44$). Blood loss and operative times were lower in the LRN cohort (7). Other recent studies have continued to demonstrate that perioperative outcomes, including operative time, blood loss, postoperative analgesia requirements, length of hospital stay, and duration of convalescence, largely favor LRN.

Laparoscopic Partial Nephrectomy

Oncologic outcomes are comparable between LPN and OPN for T1a and T1b lesions. A multicenter study evaluated 1,800 consecutive patients undergoing either laparoscopic or open PN for tumors ≤7 cm in diameter. Positive surgical margins were found in 1.6% of laparoscopic PN specimens and in 1.0% of specimens from patients who underwent the open procedure (13). Lane and Gill (14) reported long-term oncologic outcomes of laparoscopic and open PN for T1 tumors. At 7 years, cancer-specific survival for T1a tumors was 95% in both cohorts; likewise, 7-year cancer-specific survival for T1b tumors was similar for both procedures (14).

Robotic Partial Nephrectomy

Contemporary robotic PN series indicate low positive margin rates between 0% and 5.9%, which are comparable with those of OPN (1.0%) and LPN (1.6%). The excellent stereoscopic vision and the dexterity of the robotic wrist probably contribute to the low positive margin rates observed in these series. Specific long-term oncologic outcome data for robotic assisted PN are not yet available (15–22).

COMPLICATIONS

Laparoscopic Nephrectomy

Laparoscopy is the current surgical standard for routine simple and radical nephrectomy due to equivalent cancer control and complication rates with decreased patient morbidity and convalescence. Even when LN has been expanded to treat complex situations, equivalent or nearly equivalent low complication rates have been observed. It is now not only feasible but increasingly reasonable for an experienced laparoscopic surgeon to selectively use LN to treat patients with large stage T2 tumors, hilar lymphadenopathy, kidneys needing autotransplantation, bilateral renal tumors, horseshoe kidneys, ADPKD, xanthogranulomatous pyelonephritis, and profound obesity. Although da Vinci (Intuitive, Sunnyvale, California) robotic-assisted laparoscopic surgery has little role in routine LN, it may have a future role in certain complex procedures, such as caval thrombectomy.

Of importance, complications do occur at an increased rate during a surgeon’s initial learning curve. Improvements in training and skills distribution throughout the urologic community are therefore needed. Although LN has made great inroads into the academic centers, its adoption into private, community practice has lagged behind (23). Laparoscopic-naïve open renal surgeons currently in practice need to remember that a significant time investment in retraining is required to work through an approximately 20-case learning curve. It is also critical that new technology does not inappropriately supersede a more appropriate operative procedure, as is highlighted by concerns that LRN may be inappropriately replacing PN in the treatment of small renal tumors (24). Future expansion of indications for nephron-sparing surgery and robotic assistance equipment spread will progressively diminish the role of LRN.

Laparoscopic Partial Nephrectomy

Compared to OPN, LPN reduced entry trauma, demonstrating improvements in hospital stay, operative time, and recovery time compared to open surgery (13). However, early series of LPN also revealed a higher rate of complications, both urologic (such as urinary leak and hemorrhage) and nonurologic (including deep vein thrombosis and pulmonary embolism), reflecting the learning curve (25). With experience and contemporary technical refinements to the procedure (e.g., the use of hemostatic agents or bolsters), Simmons and Gill (26) reported equivalent complication rates between open and LPN in 2007. In the same study, comparison of historical versus contemporary LPN outcomes demonstrated that overall complications had decreased from 33% to 19%, occurrence of postoperative hemorrhage decreased from 9.5% to 4.5%, urine leaks reduced in prevalence from 4.5% to 2%, and nonurologic complication rates dropped from 15% to 11% (26).

Despite improvements, there remain four principal concerns with LPN: controlling hemostasis; obtaining negative margins (particularly during the learning curve); avoiding lengthy (>30 minutes) warm ischemic times and renal injury; and treating large, complex, or centrally located tumors. Robotic assistance significantly improved PN technique and at least the issues regarding ischemia time and treatment of large tumors.

Robotic Partial Nephrectomy

Complication rates in contemporary robotic PN series, even those including large, complex tumors, remain low (8.6% to 24.5%). With adequate minimally invasive expertise, robotic PN demonstrated at least equal and sometimes even better perioperative outcomes and complication rates (27–30).

In a single-institution series of 102 patients who underwent LPN or robotic PN, Wang et al. (28) reported decreased warm ischemia time (19 minutes versus 25 minutes) and shorter hospital stay (2.5 days versus 2.9 days) for the robotic PN cohort, but no difference in complication rates between the two groups. A recent study comparing 118 patients who underwent LPN with 129 patients who underwent robotic nephron-sparing surgery also found similar rates of postoperative complications between study arms (10.2% versus 8.6%) (27). In a multi-institutional study of 450 patients who underwent robotic PN, complications were stratified using the Clavien-Dindo classification system (27,32). Overall, 71 patients experienced a complication (16%); 8 complications were intraoperative and 65 were postoperative. A total of 54 complications were classified as Clavien grade I or II (12%), which required conservative management only, whereas 17 complications were Clavien grade III or IV (4%), necessitating subsequent intervention.

The rates of postoperative hemorrhage after minimally invasive PN are relatively low at <5% and are similar between laparoscopic and robotic series, with rare need for angioembolization (0.4%) (22,26). The majority of delayed postoperative hemorrhages arise from arterial pseudoaneurysm or arteriovenous fistula formation (32). As expected, with increasing tumor centrality and involvement of major vascular structures during resection, the risk of vascular anomalies also rises. Angioembolization can readily control the source of postoperative PN hemorrhage if recognized quickly and can obviate the need for operative reintervention, which carries a significant risk of radical nephrectomy. A high index of suspicion is necessary with a low threshold for angiointervention in any patient who presents with postoperative anemia or hemodynamic instability after PN.

In conclusion, LN is the current standard of care for noncancer disease and for big tumors not amenable to nephron-sparing surgery. LPN outcomes now closely approach those of OPN at elite centers but remains a challenging procedure with long learning curve. These are the reasons why it is getting supplanted by robotic PN offering the advantages of the minimally invasive approach that are desirable to patients as well as stereoscopic 3D vision and articulated instruments, which make it an ideal platform for the surgeon to treat even the most complex tumors. Novel techniques are emerging that aim to further maximize postoperative renal function by reducing, and even eliminating, surgical ischemia. The published series of robotic PN have demonstrated that it is safe and feasible, with comparable perioperative outcomes to LPN and open surgery. With the increasing incidence of small renal masses, experience with robotic PN is likely to grow and further refinements will be aimed at maximizing the trifecta of postoperative renal function, oncologic control, and perioperative outcomes.

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CHAPTER 7 ■ MINIMALLY INVASIVE NEPHROURETERECTOMY

ALON Z. WEIZER AND JEFFREY S. MONTGOMERY

EPIDEMIOLOGY

Upper tract urothelial carcinoma (UTUC) is a rare entity representing approximately 5% of all urothelial carcinomas (1). Based on Surveillance, Epidemiology, and End Results (SEER) data from 1973 to 2005, the incidence of UTUC has increased from 1.88 to 2.06 cases per 100,000 person-years. This includes an increase in ureteral tumors from 0.69 to 0.91 cases per 100,000 person-years and a slight decrease in renal pelvic tumors from 1.19 to 1.15 cases per 100,000 person-years over this time period. The increased incidence is associated with an increase in the median age at diagnosis (from 68 to 73 years old) and an increase detection of in situ disease without dramatic increases in regional or distant disease (2). Despite this, the literature suggests that approximately 60% of UTUC are invasive at the time of diagnosis (3). Roughly 2% to 5% of patients have bilateral UTUC on presentation, and up to 4% of patients will develop a contralateral UTUC at some point in their course. Although the incidence of UTUC has increased, other studies have suggested that survival has not improved. Eylert et al. (4) combined multiple data sets in England from 1985 to 2010 and found that an increased number of patients were diagnosed at more advanced stages with a decrease in 5-year overall survival from 60% to 48% over the study period.

Explanations for the increased incidence of UTUC include increased survival among patients with bladder cancer who are at risk of developing metachronous UTUC (incidence in bladder cancer patients is 0.75% to 6.4% after cystectomy) (5), the increased use of intravesical therapy especially in the setting of carcinoma in situ, and improved detection with current cross-sectional imaging and endoscopic technology. However, because there has been little change in the management of UTUC (nephroureterectomy remains the mainstay of treatment with limited data on the use of perioperative chemotherapy), the increased incidence has not been associated with a decline in mortality.

RISK FACTORS

Patients who develop UTUC share many of the same characteristics as those who develop bladder cancer. These include exposure to tobacco (6) and environmental/occupational exposures including aromatic amines (7). Several specific risk factors include chronic inflammation caused by nephrolithiasis or recurrent ascending urinary tract infections. Congenital or acquired obstruction (as seen in patients with chronic nephrolithiasis and ureteral stricture) may increase the risk of developing UTUC. Due to the rarity of the disease, it is unclear whether congenital abnormalities of the upper urinary tract such as ureteral duplication or ectopic kidneys predispose to UTUC. An increased incidence of UTUC in parts of Taiwan has been associated with blackfoot disease and exposure to arsenic in drinking water (7). *Aristolochia fangchi* and *Aristolochia clematis* contain aristolochic acid, which is found in certain Chinese herbal preparations (8) and is also endemic to the Balkans. This has been associated with UTUC and may play a role in the development of Balkan nephropathy (9). Finally, patients with hereditary nonpolyposis colon cancer (HNPCC) have an increased risk of UTUC and bladder cancer; this population requires screening for urothelial carcinoma (10).

DIAGNOSIS

The diagnosis of UTUC can be challenging. In patients without a prior history of bladder cancer, signs and symptoms typical of UTUC, including hematuria, flank pain, fever/infection, and hydronephrosis, can mimic nephrolithiasis. This becomes more confusing when patients present with a stone due to urine stasis caused by an obstructing tumor. Because the standard imaging for stone disease is a noncontrast computerized tomography (CT) scan, an UTUC may not be apparent unless it is causing a contour deformity of the kidney or the ureter. In addition, a calcified tumor may be interpreted as a stone, and if treated with shock wave lithotripsy as opposed to endoscopic management, a delay in diagnosis occurs.

In the absence of symptoms, hematuria should be evaluated according to the current American Urological Association hematuria guidelines with a CT urogram, cystoscopy, and urine cytology (11). Even in the setting of symptoms suggestive of nephrolithiasis, consideration should be made for obtaining a urine cytology, especially if the patient has risk factors for bladder cancer (although nephrolithiasis can cause cytologic atypia). Pursuit of cross-sectional imaging with a contrast-enhanced excretory phase or endoscopic visualization should be considered if symptoms persist. Finally, recalcitrant irritative voiding symptoms presumed to be caused by a urinary tract infection treated with a course of culture-directed antibiotics warrant further evaluation for urothelial carcinoma with cystoscopy, upper tract imaging, and cytology. For patients who cannot undergo CT with contrast due to compromised renal function, magnetic resonance (MR) urogram can be considered if their estimated glomerular filtration rate (eGFR) is ≥30 mL per minute. For those with eGFR <30 mL per minute, magnetic resonance imaging (MRI) of the abdomen/pelvis without gadolinium, noncontrast CT scan, or renal ultrasound can be informative but should be coupled with retrograde pyelograms and possible ureteroscopy to complete a full evaluation of the urinary tract.

Several options for diagnosis exist if a patient has a filling defect in the upper urinary tract or positive urine cytology without visible signs of disease in the bladder on cystoscopy. We believe that a filling defect on imaging studies with a positive selective cytology from that upper urinary tract is adequate to make the diagnosis of UTUC. Ureteroscopy with biopsy can still be performed but may not be necessary in the setting of a large filling defect and positive selective cytology. Alternatively, image-guided percutaneous biopsy can be considered for bulky upper tract masses. Although some contend that tumor seeding of the biopsy tract is a possibility, there may be a risk of lymphatic dissemination of tumor due to use of pressurized irrigation with ureteroscopy (12). We have not seen tumor tract seeding when employing a biopsy sheath during percutaneous biopsy. For patients with a positive cytology but without visible signs of disease, random bladder and prostatic urethral biopsies should be obtained in addition to ureteroscopy with ureteral barbotage cytology to rule out the possibility of occult disease in these locations. Use of ureteral brushes or other biopsy tools are helpful in obtaining an adequate cytologic or tissue diagnosis in the upper urinary tract.

Patients with UTUC should undergo additional staging to assess for metastatic disease. This includes a chest X-ray or chest CT, complete blood count, and comprehensive metabolic panel (including liver function tests and an alkaline phosphatase). These can help guide the need for additional imaging including nuclear medicine bone scan to assess for bony metastasis and chest CT if the chest X-ray is concerning. Symptoms of bone pain may also guide the use of a bone scan, regional plain films, or selective MRI or CT depending on location.

Patients with a prior history of bladder cancer warrant special consideration. Microscopic or gross hematuria, persistent urinary symptoms, or abnormalities on urinalysis despite treatment for urinary tract infection warrant additional evaluation. Urine cytology should be part of standard surveillance for patients with a history of bladder cancer. For patients with an intact bladder and prior endoscopic and/or intravesical bladder therapy, upper tract imaging should be performed prior to any biopsy. In situations with no obvious bladder recurrence, endoscopic evaluation should include bladder and prostatic urethral biopsies as well as retrograde pyelograms, selective upper tract cytology, and ureteroscopy. Cystectomy patients, especially with a history of carcinoma in situ, should undergo a CT or an MR urogram if possible. If this is not possible due to poor renal function, MRI of the abdomen and pelvis, loopogram (for ileal conduit), or cystogram (for neobladder) may help identify an upper tract lesion. Upper urinary tracts not accessible by retrograde ureteroscopy may warrant a percutaneous antegrade approach to identify disease.

ALTERNATIVE THERAPY

Nephroureterectomy is considered the standard treatment for UTUC. However, there are several patient and disease factors that obligate alternative or interim approaches. There is a large percentage of UTUC patients with compromised renal function (13), and nephroureterectomy may necessitate dialysis. Renal function may be compromised by medical renal disease related to smoking, hypertension, diabetes, or cardiovascular disease or may be due to prior surgical intervention for upper tract disease. In addition, the disease itself may influence initial treatment strategies. Because of the difficulty in accurately assessing the stage (i.e., depth of invasion) of UTUC, grade is used to assess the potential aggressiveness of the disease. Patients with low-grade focal tumors of the renal pelvis or ureter may be managed with endoscopic approaches. Ureteroscopy is often the most straightforward option. There are various tools that can be used for both resection and ablation of these lesions. In order to get adequate tissue for diagnosis, we tend to use an access sheath and backload the BIGopsy device (Cook, Bloomington, Indiana). This is especially useful for proximal ureteral and renal pelvis tumors. For more distal tumors, a semirigid ureteroscope is used with a biopsy forceps. We often combine biopsy with ureteral wash cytology, and for flat lesions, ureteral brushings. Both a holmium laser as well as ureteroscopic Bugbee electrode (2Fr) can be used for lesion ablation. For larger low-grade collecting system tumors, percutaneous resection can be considered because the risk of tumor seeding is low with these tumors. Access is achieved in the identical fashion to percutaneous nephrolithotomy. For lower and interpolar lesions, direct access to the tumor with the use of a resectoscope can allow for complete endoscopic removal and hemostasis.

However, occasionally due to angulation and narrow calyceal diameter, the tumor cannot be accessed with a resectoscope and a flexible nephroscope with biopsy forceps, laser, or Bugbee are needed to manage the lesion. In patients with previous urinary diversion, antegrade percutaneous renal access may be necessary if retrograde access is not possible.

Patients with focal but high-grade tumors may benefit from endoscopic therapy in addition to adjuvant intraurinary chemo/immunotherapy to reduce the risk of recurrence and progression. Although several approaches have been described, we believe that placement of a nephrostomy tube and antegrade instillation is the most reliable approach. Other options include placement of an indwelling ureteral stent with intravesical instillation (relying that the medication will reflux into the upper tract) or retrograde placement of an externalized ureteral catheter prior to each treatment with instillation of the medication via this catheter. This strategy is both cumbersome and time-consuming for the urologist and the patient. Similar to high-grade, non–muscle-invasive bladder cancer, the preferred intraurinary treatment for high-grade papillary tumors and carcinoma in situ upper tract disease is bacille Calmette-Guérin (BCG). Approximately, 30% of patients recur following upper tract instillation with a median follow-up of >20 months in a review by Carmignani et al. (14). Options for second-line therapy for those who fail an initial induction course of BCG include a second induction course of BCG (+/− interferon) or instilled chemotherapy (e.g., mitomycin, gemcitabine, docetaxel). Managing high-grade disease conservatively, however, carries risk of incomplete treatment and disease progression and therefore should be driven by patient life expectancy, extent of disease, renal function, and potential additional morbidity of nephroureterectomy. The risk of recurrence is high (as much as 80%) making nephroureterectomy the preferred treatment option for patients with high-grade disease (14).

When endoscopic management is performed for UTUC, a strategy of surveillance with endoscopy is necessary to evaluate for recurrence and metastases. Patients should undergo three-dimensional cross-sectional imaging at least yearly to evaluate for possible metastases. Patients managed conservatively at first do not appear to have worse outcomes when compared to patients managed with nephroureterectomy initially (15).

Patients with bilateral high-grade upper tract disease present a unique challenge and often require bilateral nephroureterectomy. Although recent data suggests that patients requiring dialysis for postsurgical indications have better outcomes than those requiring dialysis for medical renal disease, the substantial effect that dialysis has on patient quality of life needs to be considered (16). Also, with a history of UTUC, patients must be free of disease recurrence for at least 2 years prior to being listed for renal transplant.

Lesions of the distal or midureter may be managed by segmental resection with data suggesting similar cancer control to nephroureterectomy (17). Details of this approach are discussed elsewhere in this book. However, we have found that robotic-assisted approaches are effective with good outcomes for patients undergoing distal ureterectomy, psoas hitch, and/or Boari flap reconstruction with the ability to remove as much as two-thirds of the ureter. In addition, lymphadenectomy can be performed at the time of the procedure. In patients with bulky or locally advanced disease, neoadjuvant chemotherapy should be considered as the presence of both kidneys and preserved renal function allows for optimal chemotherapy dosing (18). However, there is currently no prospective, randomized evidence to support this approach. The same cisplatin-based regimens that are used for invasive bladder cancer are typically employed in this setting.

Finally, in those patients who have unresectable disease or are poor surgical candidates, palliative management should be driven by patient goals and symptoms. Early referral to specialists in palliative care is important to avoid unnecessary interventions. The most common symptoms seen in patients with locally advanced disease are pain and hematuria, with or without clot retention and the need for blood transfusion. Palliative radiation can effectively manage pain and gross hematuria caused by unresectable UTUC in select patients. Given the extensive vascular network supplying the renal pelvis and ureter, renal angioembolization often fails to control hematuria arising from UTUC.

INDICATIONS FOR SURGERY

After considering the treatment alternatives presented earlier, patients with localized high-grade Ta-T4 urothelial carcinoma are suitable candidates for nephroureterectomy. The decision on how best to approach nephroureterectomy depends on the extent of the disease and the skillset of the surgeon. There are no absolute indications for open versus a minimally invasive (i.e., laparoscopic, hand-assisted, or robotic) approach. However, there are several clinical circumstances that can help guide this decision. Most of the published literature indicates that the oncologic outcomes for open and minimally invasive nephroureterectomy are similar. An open approach has traditionally been advocated for patients with significant pulmonary disease due to the concern for absorption of carbon dioxide during laparoscopy that would result in patient hypercarbia. There are two issues with this teaching. First, the open incisions used for nephroureterectomy can result in significant abdominal pain that can compromises the depth of patient inspiration during recovery. Second, a hand-assisted approach in this patient population can hasten the procedure and allow the insufflation pressure to be reduced (10 mm Hg), limiting carbon dioxide absorption while still providing patients the recovery benefits of laparoscopy. Patients who cannot tolerate a hand-assisted nephroureterectomy are likely not appropriate surgical candidates. Other relative indications for open surgery include bulky disease, presence of lymphadenopathy, as well as prior extensive endoscopic management that could result in significant perinephric inflammation. Although these procedures are more challenging, we believe they are still amenable to minimally invasive approaches at the discretion of the surgeon.

Selecting a hand-assisted, conventional laparoscopic, or robotic approach also depends on the surgeon’s experience, but patient and disease characteristics influence this decision. In general, we employ a hand-assisted approach when patient comorbidities dictate an expeditious procedure or when tactile perception would be advantageous (e.g., bulky specimens or perirenal inflammation). For patients with renal pelvis tumors, we often combine an endoscopic approach for the management of the bladder cuff with a hand-assisted approach. An endoscopic bladder cuff can also be used with a conventional laparoscopic approach. We do not recommend performing an endoscopic bladder cuff for distal ureteral tumors because of risk of tumor spillage. In the case of large distal tumors, combining a conventional laparoscopic approach for the nephrectomy portion with a lower midline or Gibson incision to perform an open distal ureteral dissection and bladder cuff avoids a single large incision or two separate incisions. This is especially useful when managing upper tract recurrences in patients with a urinary diversion where the distal ureteral anatomy is often distorted and prior surgery creates scarring around structures such as the iliac vessels or bowel.

For most patients, robotic-assisted nephroureterectomy is our preferred approach. The advantages of this approach include (a) techniques have been described that obviate patient repositioning during the case (although we do reposition the robot but not the patient), (b) the location of the extraction incision can be tailored to the patient, (c) a robust lymphadenectomy can be performed, and (d) a watertight bladder closure can be achieved once the distal ureter and bladder cuff are excised. In our experience, the primary disadvantage of the robotic approach is longer average operative times compared to laparoscopic approaches. The appropriate nephroureterectomy approach is the one that best allows the individual surgeon to adhere to oncologic principles.

SURGICAL TECHNIQUE

Patient Preparation

Although there are some differences in patient positioning and surgical technique by approach selected, patient preparation is similar for all patients undergoing minimally invasive nephroureterectomy. Staging is performed for all patients as described earlier including cross-sectional imaging combined with upper tract opacification (Fig. 7.1). This allows for the accurate anatomic evaluation of any upper tract disease, definition of the renal hilar vascular anatomy as well as the presence of lymphadenopathy or solid organ metastases. In addition, patients undergo preoperative lab evaluation with a comprehensive metabolic panel including liver function tests, complete blood count, coagulation panel, electrocardiogram, and blood type and screen. We do not cross-match for blood products given the low incidence of blood transfusion associated with this procedure. In addition, patients undergo preoperative evaluation by anesthesiology with directed evaluation by cardiology, pulmonology, or other medical services as indicated. Mechanical bowel preparation is not necessary; a clear liquid diet beginning 24 hours prior to surgery with nothing by mouth 4 hours prior to surgery is recommended.

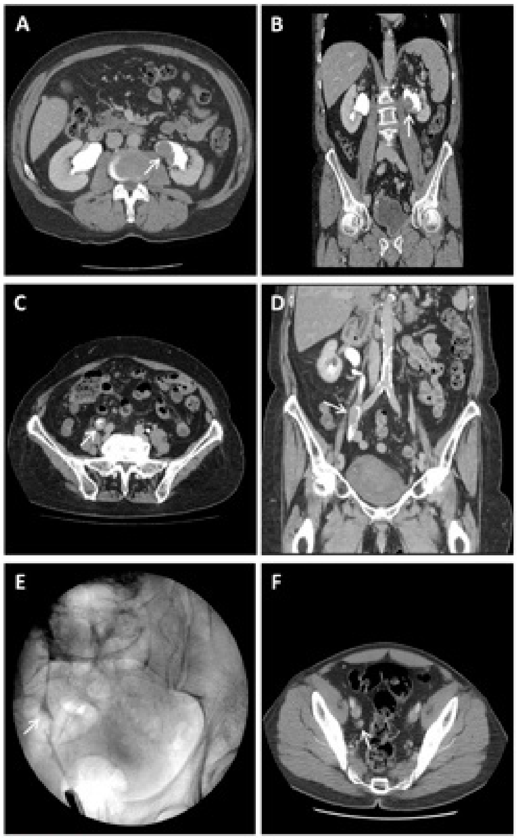

FIGURE 7.1 Upper tract urothelial carcinoma. Tumor location indicated with *arrows* in each image. Transverse (A) and coronal (B) views of a large renal pelvis tumor on CT urogram excretory phase. Transverse (C) and coronal (D) CT urogram view of a tumor occupying most of the midureter. A classic "goblet sign" on retrograde pyelogram (E) of a right-sided distal ureteral tumor. This same tumor on a transverse section of a contrast-enhanced CT (F).

Obtaining informed consent from the patient, including a description of the procedure along with a discussion of the surgical risks is a crucial step. The general risks of this procedure include bleeding requiring blood transfusion, infection (e.g., abscess, urinary tract infection, wound infection), damage to surrounding structures (e.g., bowel, blood vessels, nerves, bladder, pancreas and depending on the side of the procedure, liver or spleen), bladder urine leak requiring prolonged drainage, disease recurrence, and need for additional treatments.

Although we prefer that all other antiplatelet medications be discontinued 5 to 7 days prior to surgery, there is good data to support continuation of at least 81 mg of aspirin throughout the perioperative period in patients with prior cardiac stenting. In fact, discontinuation of aspirin likely increases the risk of a cardiac or thromboembolic events in surgical patients (19).

It is critical to ensure that any urothelial disease within the bladder is controlled prior to nephroureterectomy. Although cystoscopy can be performed at the time of the nephroureterectomy to evaluate the bladder, if disease is found, there is limited ability to determine whether the bladder pathology would influence surgical decision making. As such, we recommend office cystoscopy at least 2 weeks prior to surgery so that bladder tumors can be resected and staged. In addition, some groups have reported on the use of perioperative intravesical mitomycin at the time of nephroureterectomy to reduce the risk of bladder recurrence, which has been reported to be as high as 30% (20).

Patient Positioning

A surgical beanbag is placed on the operating table with a drawsheet above and below the beanbag to facilitate proper positioning. The patient is initially in the supine position on the table. Intravenous antibiotics to cover skin flora are administered within 1 hour of surgical incision. We routinely use 5,000 units of subcutaneous heparin in addition to lower extremity sequential compression devices for venous thromboembolic prophylaxis. After induction of general anesthesia, a Foley catheter is placed as well as an orogastric tube to minimize the risk of injury to the viscera when accessing the abdominal cavity. We ensure that the circulating nurse has access to the catheter in the event that the bladder needs to be filled during the procedure. In cases where an endoscopic bladder cuff approach is used, the Foley catheter is placed following this portion of the procedure.

Prior to positioning, it is important to assure that there are sufficient members of the operative team available to lift and secure the patient. The patient is brought to a modified lateral decubitus position with the operative side elevated at a 45- to 60-degree angle from the horizontal plane. The downside knee is flexed at the knee and hip, the upside leg is straight and parallel to the floor, and pillows are placed between the legs and also on the table to support the upside ankle. Some surgeons choose to position the patient’s iliac crest over the table break and mildly flex (15 to 30 degrees) the table to lengthen the space between the costal margin and iliac crest. An axillary roll is generally not necessary, but it should be assured that the downside axilla is not compacted against the operating table to avoid a brachial plexus injury. The upside arm is secured on an elevated arm board in an anatomic position, assuring that it will not obstruct the movement of the surgical instruments during the case. The downside arm is supported with a table-level, detachable arm board. Assure that there are no tubes or cords under the patient or under any securing tape or straps because these can cause pressure necrosis during the case. The beanbag is then formed along the patient’s sides to support this position, and air is evacuated from the beanbag to secure it in place. All pressure points are padded and 3-inch padded cloth tape is brought over the hips and across the chest just below the axilla to firmly secure the patient to the table but avoiding compression (Fig. 7.2). The surgical, anesthesia, and nursing teams should evaluate the patient to assure proper positioning and support. The abdomen, flank, and lower chest are sterilely prepped and draped so that the boundaries of the operative field include the midchest, superiorly; posterior axillary line, laterally; beyond the umbilicus, medially exposing the midline; and the pubic symphysis, inferiorly. Prior to the initial incision, a surgical verification is performed to confirm the correct patient, surgical site (marked in the preoperative holding area), antibiotics given, appropriate equipment, surgical team introductions, fire safety assessment as well as risk-based venous thromboembolism prophylaxis.

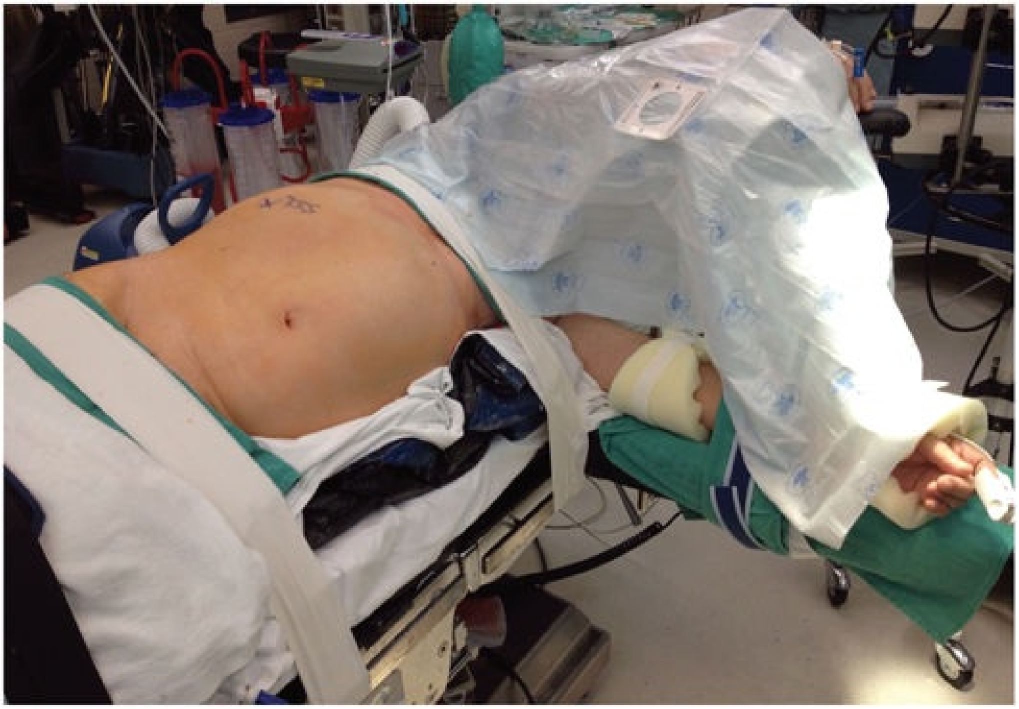

FIGURE 7.2 Our standard patient positioning for all of our minimally invasive nephroureterectomy approaches. The patient is at a 60-degree angle to the operating table, supported with a beanbag and padded tape. The ipsilateral arm is supported on an elevated arm board and the contralateral arm on a bed-level arm board. Both arms are padded at pressure point, secured in place, and draped an upper body warming apparatus.

Transperitoneal Laparoscopic Radical Nephroureterectomy

Although minimally invasive retroperitoneal nephroureterectomy has been reported in small series (21), the majority of minimally invasive nephroureterectomies are performed via a transperitoneal approach. The transperitoneal approach offers a larger working space as compared with the retroperitoneoscopic approach. Transperitoneal options include conventional laparoscopic, hand-assisted, and robotic techniques. All of these approaches offer the patient the benefits of a minimally invasive procedure; the approach selected is most influenced by the surgeon's experience and comfort level with a specific technique.

For all approaches, the abdominal and pelvic cross-sectional staging imaging should be reviewed, preferably available in the operating room at the time of surgery, to note the patient's anatomy. Special attention should be paid to the renal hilum, identifying any complexity of the renal vasculature to aid in surgical planning. The surgeon should once again assure that there are no signs of metastatic disease or lymphadenopathy which may indicate that the patient should receive neoadjuvant chemotherapy.

Conventional Laparoscopic Nephroureterectomy

Initial abdominal access is gained either via a Veress needle technique, open Hasson technique, or with a direct optical trocar technique (http://www.auanet.org/common/pdf/education/BLUS-Handbook.pdf). There are multiple effective port configurations, and this is left to individual surgeon preference and experience. Figure 7.3 shows the suggested port placement for a conventional laparoscopic approach. An incision is made approximately 1 cm to the ipsilateral side of the umbilicus, and the abdomen is accessed with a Veress needle. If the patient has had previous abdominal surgery, access is gained at a site away from incision lines to avoid bowel adhesions. A 5-

mm or 10/12-mm camera port (depending on camera lens size available) is placed at this site. Under laparoscopic vision, a 10/12-mm working port is placed at the level of the umbilicus just lateral to the rectus muscle, a 5-mm working port is placed 2 cm below the medial aspect of the ipsilateral costal margin, and a 5-mm assistant port is placed in the ipsilateral axillary line 2 to 3 cm superior to the anterior superior iliac spine. This port configuration is similar to that for a laparoscopic nephrectomy with the notable addition of a 5-mm or 10/12-mm port in the midline between the umbilicus and pubic symphysis to allow for the dissection of the distal ureter.

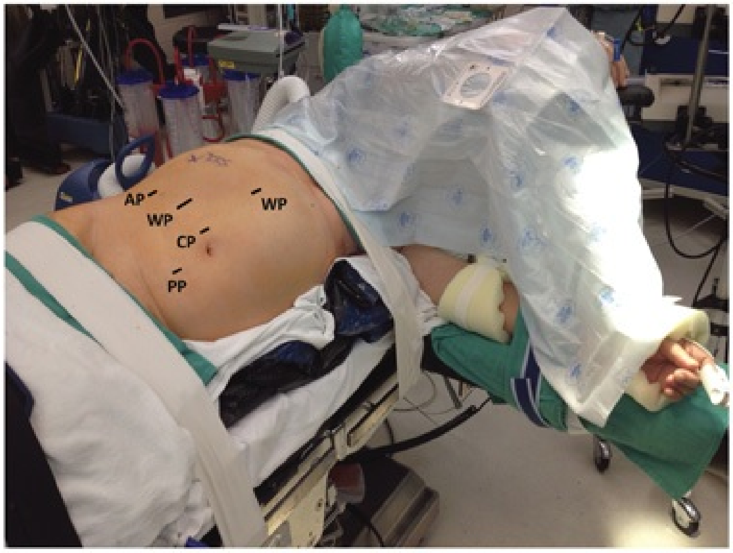

FIGURE 7.3 The suggested port configuration for a conventional laparoscopic nephroureterectomy. *AP*, assistant port; *CP*, camera port; *PP*, pelvic port; *WP*, working port.

There are some important general principles when deciding on port placement for a conventional laparoscopic nephroureterectomy and individual port locations may vary according to each patient's body habitus:

1. An ergonomic configuration for the surgeon and assistant is of utmost importance to assure comfort and avoid surgeon injury.
2. For obese patients, the port configuration should be displaced laterally to assure optimal access for dissection.
3. For patients with compact abdominal surface areas, it may be prudent to flex the patient to expand the operative space.
4. It may be necessary to alter the port locations to assure adequate spacing between the ports (i.e., approximately 5 cm or 1 fist-breadth apart).
5. It may also be necessary to move the lateral assistant port toward the midclavicular line or down into the pelvis to achieve proper spacing.

The dissection begins by sharply (with judicious use of cautery to maintain hemostasis) incising along the white line of Toldt and reflecting the colon medially to expose the surface of Gerota fascia, taking care not to enter the colon mesentery. On the left side, this portion of the dissection is generally more extensive and involves releasing the lateral colonic attachments down into the pelvis and along the spleen. On the right side, care should be used when kocherizing the duodenum off of the medial aspect of the Gerota, renal hilum, and vena cava. Focusing on the lower pole of the kidney, the space is developed posteriorly, lateral to the great vessels, to expose the psoas muscle. The lower pole Gerota containing the ureter can then be elevated by the assistant surgeon with a laparoscopic sucker or grasper. Within this elevated tissue, the gonadal vein and ureter can be exposed. For renal and proximal ureteral UTUC, the ureter can be clipped at this time. For more distal tumors, the ureteral dissection can be carried inferiorly until the surgeon is beyond the site of the tumor to clip the ureter to avoid migration of tumor cells into the bladder.

On the right side, the gonadal vein should be reflected medially from the specimen. The para-aortic lymphadenectomy for left renal and proximal ureteral tumors can be facilitated by including the gonadal vein with the specimen. For distal left-sided tumors, the gonadal vein can be reflected medially from the specimen. The inferomedial and posterior dissection is carried superiorly to the renal hilum. On the left side, beware of lumbar veins that variably course to the renal and/or gonadal vein. Elevating the lower pole of the kidney to put the renal hilum on stretch, space is made superior and posterior to the renal hilum to allow adequate access for a laparoscopic stapling device. We generally staple the renal artery and vein en bloc, although these vessels can be separately isolated and stapled at the surgeon's discretion. It is important to avoid the use of clips around the renal hilum prior to stapling to avoid entrapping clips in the staple load, causing staple malfunction and possible vascular catastrophe. It is also important to assure that additional staple loads are available in the room prior to stapling the hilum.

With the hilum controlled the dissection proceeds along the superomedial boarder. If there is no concern for adrenal involvement with disease, the adrenal gland can be dissected free of the specimen by incising into the Gerota fascia at the medial edge of the adrenal. To maintain hemostasis, cautery or another energy source should be freely employed during this portion of the case. Once the adrenal is released, the plane of dissection should once again continue outside of the Gerota fascia to free the upper pole of the specimen. The lateral side wall attachments are then released to free the renal portion of the specimen. The ureteral dissection is then carried as inferiorly as possible. The management of the intramural ureter and bladder cuff as well as lymphadenectomy will be described later in this chapter. The specimen should be entrapped in a laparoscopic sack to avoid specimen fracture and tumor spillage during extraction. A round drain is brought into the abdomen via the 5-mm lower quadrant port and draped in the pelvis. The end of the entrapment sack suture is brought through the 12-mm working port. If an additional 12-mm port is used, the fascia at this site is closed with 0-polyglactin suture using a Carter-Thomason device. The remaining ports are removed under direct vision. The camera port incision is extended to allow the removal of the specimen in the entrapment sack. The extraction site fascia is closed with two individual, running no. 1 looped polydioxanone sutures beginning at the apices of the incision. The subcutaneous tissue along all incisions is infiltrated with 0.5% Marcaine. The incisions are irrigated and the skin is closed with 4-0 Monocryl suture and overlying Indermil (Henkel, Dusseldorf, Germany) glue. A drain sponge is placed, and the drain is secured to the skin with a nylon suture.

Hand-Assisted Nephroureterectomy

Because an incision is necessary for specimen extraction with laparoscopic nephroureterectomy, making this incision at the beginning of the case to allow for the use of the surgeon's hand during the case makes the dissection more expeditious. In addition, having a hand in the abdomen may make more surgeons comfortable with offering patients a minimally invasive approach. Additional advantages of the hand-assisted over the conventional laparoscopic approach include the following:

1. The surgeon's hand can be used to gain vascular control in the event that bleeding occurs during the procedure.
2. The hand facilitates dissection through retraction and blunt dissection.
3. Ports can be placed under direct vision with the hand supporting the abdominal wall to avoid injury to the viscera.
4. A laparotomy sponge can be placed through the hand port to assist with hemostasis and visualization.
5. Additional ports can be placed through the hand port as needed to facilitate the course of the

dissection.

There is evidence that the rate of wound complications is higher with the hand-assisted approach as compared with the conventional laparoscopic approach with incision and intact specimen extraction at the conclusion of the procedure, presumably due to prolonged local wound trauma at the hand-port site (22). Hand-port complications (e.g., infection, hernia, and dehiscence) are associated with patient obesity, history of smoking, prolonged operative time, and omission of perioperative antibiotics.

With the patient supine prior to positioning, it is helpful to mark the patient's midline with a permanent marker to assist with midline hand-port placement. The patient is positioned and secured as described earlier. After the patient is prepped and draped, the patient is rotated approximately to a horizontal position with the surgeon and assistant standing on opposite sides of the patient. The hand port should be placed in a location that allows the surgeon to reach above the upper pole of the kidney and down into the pelvis for the ureteral dissection. Most commonly, the optimal placement is in a periumbilical location, with an equal amount of the hand port above and below the umbilicus (Fig. 7.4), but this can be adjusted superiorly or inferiorly as needed. In obese patients, the hand port may need to be placed in a paramedian location. The length of the hand-port incision corresponds to the diameter of the surgeon's hand and forearm—on average 8 cm. The camera port (5 mm or 10/12 mm, depending on lens size available) is placed inferior and slightly lateral to the hand port to allow visualization of the upper retroperitoneum for the nephrectomy portion of the case and the pelvis for the ureterectomy portion of the case. A surgeon working port is placed approximately 4 cm above the midline of the hand port and an assistant port is placed approximately 2 to 3 cm superior and medial to the anterior superior iliac spine (ASIS). At least one of these should be a 10/12-mm port depending on the angle at which the surgeon elects to control the renal hilum—parallel to the great vessels from the ASIS port or more perpendicular to the great vessels from the superior port. For right-sided procedures, a 5-mm port may be placed inferior to the xiphoid for use of a liver retractor as needed. Finally, a midline pelvic port is placed to facilitate the dissection of the distal ureter (see Fig. 7.4).

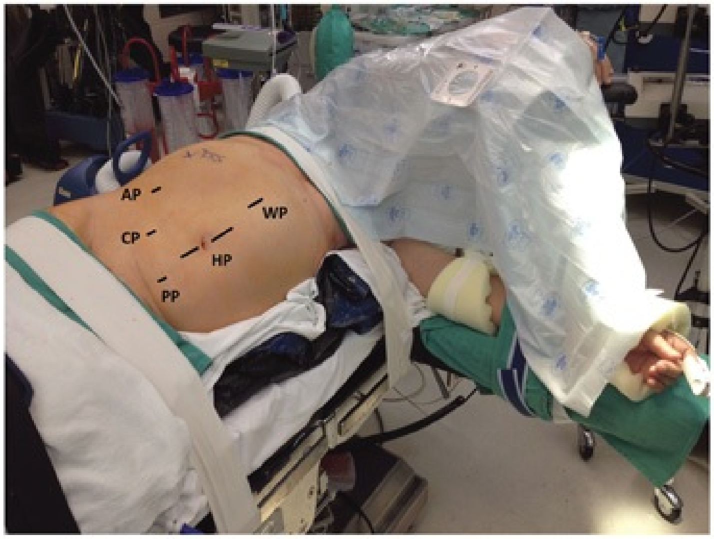

FIGURE 7.4 Hand-assisted laparoscopic nephroureterectomy port placement. *AP*, assistant port; *CP*, camera port; *HP*, hand port; *PP*, pelvic port; *WP*, working port.

The nephrectomy portion of the case proceeds as described earlier, with early clipping of the ureter below the level of the tumor and control of the renal hilum. Inserting the surgeon's hand that corresponds to the side of the procedure for the nephrectomy portion (e.g., left hand for left-sided tumor) has been described. We feel that it is more ergonomic to insert the hand opposite the side of the specimen for the nephrectomy and swapping hands for the ureteral dissection. Once the specimen is freed, it is placed in a laparoscopic sack for extraction. A round drain is brought into the abdomen via the ASIS port and draped in the pelvis. The hand port is removed and the specimen is retrieved via the hand-port site. The closure proceeds as described previously.

Robotic-Assisted Laparoscopic Nephroureterectomy

Robotic-assisted laparoscopic nephroureterectomy was first reported in 2006 (23,24). The advantages of the robotic approach include the following:

1. Three-dimensional, 10× magnified vision
2. Wristed instrumentation with 7 degrees of freedom
3. Intracorporeal bladder cuff with watertight closure, avoiding the need for additional procedures or incisions to complete the dissection
4. Improved surgeon ergonomics with a seated operating position

There are several reported techniques for robotic nephroureterectomy with various recommendations for patient positioning, port placement, and need for robot redocking to perform the nephrectomy and distal ureteral/bladder cuff dissection. The techniques include putting the patient in a partial flank position, docking the robot over the patient's ipsilateral shoulder to perform the nephrectomy portion and repositioning the patient in low lithotomy and Trendelenburg and redocking the robot between the legs for the distal ureteral dissection and bladder cuff (25); having the patient in partial flank and low lithotomy for the entire case, rotating the patient to approximate a supine position along with Trendelenburg and redocking the robot between the legs for the distal ureteral dissection without repositioning the patient (26); and placing the patient in full or partial flank position, docking the robot from the ipsilateral side of the patient, without repositioning of the patient or robot cart (27,28). Herein, we describe our technique for robotic nephroureterectomy but acknowledge that the earlier approaches are appropriate options. Ultimately, patient positioning and port placement are subject to surgeon experience and preference. With an experienced robotics team, the time needed to reposition the robot cart and redock the robotic arms is negligible if a technique that requires redocking is used.

The patient is positioned and secured in the lateral decubitus position as described earlier. To avoid clashing of the camera with the ipsilateral arm during the distal ureteral resection and bladder closure, we tuck this arm to the patients' side in an anatomic position, pad it with foam, and secure it with tape. The operating table is rotated 45 degrees around the vertical access (clockwise for a left-sided procedure and counterclockwise for a right-sided procedure). The abdomen is accessed with a Veress needle medial to the lateral rectus line at the level of the umbilicus and insufflated to 15 mm Hg. A 12-mm camera port is placed at this site. Under laparoscopic vision, a second 12-mm assistant port is placed 4 cm above the umbilicus. Four 8-mm robotic ports are placed: robotic port #1 approximately 8 cm above the camera port in the lateral rectus line; robotic port #2 approximately 8 cm inferior and lateral to the camera port in line with the ASIS in the midclavicular line; robotic port #3 is placed approximately 4 cm superior and medial to the ASIS; and robotic port #4 approximately 4 cm to the contralateral side and below the umbilicus (Fig. 7.5).

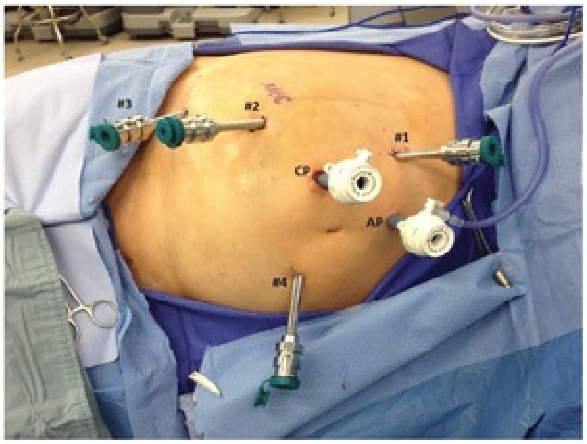

FIGURE 7.5 Port configuration for a robotic-assisted laparoscopic nephroureterectomy. *AP*, assistant port; *CP*, camera port. The 8-mm robotic ports are numbered as indicated in the text.

The robot is docked at a 45-degree angle from the head of the bed over the ipsilateral shoulder for the nephrectomy and proximal ureteral dissection. The monopolar curved scissors are placed in robotic port #1; the fenestrated bipolar grasper is placed in robotic port #2, and the ProGrasp forceps in robotic port #3. Robotic port #4 is used as a supplemental assistant port. The course of the nephrectomy portion of the procedure proceeds as described earlier. After freeing the nephrectomy specimen, the ureter is dissected as distally as possible from this position, usually to the level of the common iliac vessels. If the tumor is in the collecting system or proximal ureter, a retroperitoneal lymph node dissection can be complete in this position.

The robot is undocked, and the patient is rotated on the operating table toward the side of disease to approximate a supine position. The patient is placed in 30 degrees of Trendelenburg prior to redocking for the distal dissection to bring the bowel out of the pelvis. The fourth robotic arm is swung around to the opposite side of the robot, and the robot is redocked over the ipsilateral hip at the 45-degree angle from the foot of the bed. The monopolar, curved scissors is placed via port #2, the bipolar grasper via port #4, and the ProGrasp via port #3. Port #1 acts as a supplemental assistant port during ureterectomy portion of the procedure (see Fig. 7.5). The ureter is dissected down to the level of the bladder, leaving as much periureteral tissue on the specimen as possible. For distal ureteral tumors, a clip is placed distal to the site of the ureteral tumor to prevent tumor migration to the bladder and spillage. With the superior vesicle artery lateral, the intramural ureter is freed from the bladder until the ureteral orifice is at the apex of a cone of bladder mucosa indicating that the entire length of the ureter has been dissected free. The cone of bladder mucosa is the bladder cuff. Above the bladder cuff in the detrusor muscle, a 2-0 polyglactin suture is placed as a stay stitch. The bladder cuff is resected, and the kidney and ureter are placed in a laparoscopic extraction sack to be removed at the conclusion of the case. The bladder is then closed in two layers with running 2-0 polyglactin suture, with the stay suture closing the internal layer. The bladder is then irrigated with at least 200 mL of fluid to assure a watertight closure. For distal ureteral tumors, a pelvic lymph node dissection can be completed.

The robotic arm is released from port #3, and a round drain is placed in the pelvis through this robotic port. The robot is then undocked, and the procedure is converted to laparoscopy. The end of the entrapment sack stitch is brought through the supraumbilical 12-mm port. The incision is enlarged to extract the specimen, and the incisions are closed as described earlier.

Approaches to the Distal Ureter

Several approaches to the distal ureter and bladder cuff dissection have been described. The approach used depends mostly on the surgeon’s experience and preference, but tumor location should also be considered. There are several retrospective case series that report outcomes comparing various approaches to the distal ureter, but there is no level 1 data advocating one approach over another regarding oncologic efficacy. The approach used likely has negligible influence on patient outcomes, but the entire length of ureter, including the ureteral orifice and the surrounding bladder cuff, needs to be included in the nephroureterectomy specimen. There is a “field effect” associated with urothelial carcinogenesis (29), so the *entire extent* of the urothelium, including the distal ureter, is at risk for developing metachronous disease. In cases in which tumor subsequently develops in a retained distal ureter, management is quite difficult and may even require cystectomy.

The classic (intravesical) approach to the distal ureter includes an open incision, generally a suprapubic midline approach, bivalving the bladder, and circumferentially dissecting the bladder cuff and intramural ureter free from the bladder (30). The bladder cuff cystotomy is closed in at least two layers from inside the bladder using polyglactin suture, closing the detrusor muscle and then the overlying bladder mucosa. Polyglactin suture is also used to close the bivalved bladder and the posterior extravesical ureteral hiatus to further reinforce the cystotomy closure. The bladder is then irrigated with at least 200 mL of fluid via an indwelling catheter to assure the bladder is watertight.

To avoid bivalving the bladder, the open extravesical approach is an option as well. As the distal ureteric dissection proceeds, the ipsilateral obliterated umbilical ligament and superior vesicle pedicle are ligated and divided. The posterior bladder is rotated anteriorly and medially, dissecting the intramural ureter free from the bladder until a cone of bladder mucosa is seen surrounding the ureteral orifice situated at the apex of the cone. The bladder mucosa at the base of the cone is clamped with a right angle, excised, and the cystotomy is closed in at least two layers and confirmed to be watertight.

A transurethral approach to the distal ureter is commonly used, especially for hand-assisted and conventional laparoscopic nephroureterectomy cases. Generally, this is performed at the beginning of the procedure with the patient in the modified dorsal lithotomy position, placing a bladder catheter at the conclusion and repositioning the patient for the kidney and proximal ureteral dissection. The intramural ureter can be excised using a resectoscope with electrocautery loop back to perivesical fat (31) or cored out by incising the periureteral tissue using a 45-degree Collins knife (Fig. 7.6) (32). For both of these approaches, once converted to laparoscopy and after the nephrectomy is performed, the ureter is dissected down to the level of the bladder and the previously dissected intramural ureter is “plucked” from the bladder.

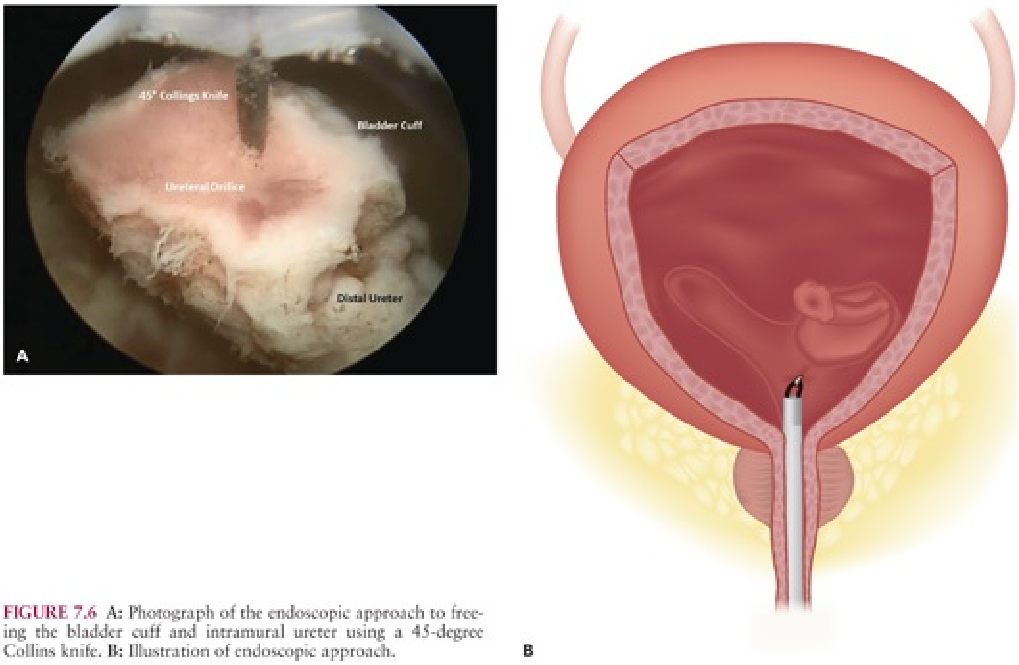

FIGURE 7.6 A: Photograph of the endoscopic approach to freeing the bladder cuff and intramural ureter using a 45-degree Collins knife. B: Illustration of endoscopic approach.

Other approaches to the distal ureter during laparoscopic nephroureterectomy include ureteral stripping and stapling. For the ureteral stripping (intussusception) technique, a ureteral catheter is placed endoscopically at the beginning of the case (33). The ureter is transected distally during the intracorporeal portion of the case, and the ureteral catheter is secured in place in the remaining distal ureter. At the conclusion of the case, the patient is repositioned in dorsal lithotomy, and a resectoscope is placed in the bladder. The ureteral catheter is pulled until the ureter is intussuscepted into the bladder and an endoscopic bladder cuff is obtained by circumferentially incising around the everted ureteral orifice. The stapled technique of managing the distal ureter involves the dissection of the ureter distally to the point that, under vision, the cone of bladder mucosa around the ureteral orifice is seen and then stapled using a laparoscopic stapler, similar to the extravesical open approach. Alternatively, the ureter is stapled as distally as possible laparoscopically. The intramural ureter is resected endoscopically either at the beginning or end of the procedure. From an oncologic sense, any stapling technique should be avoided in situations involving distal or intramural ureteral tumors because having a retained portion of distal ureter can result in dire consequences.

The robotic approach to the distal ureter is discussed earlier. It recapitulates the extravesical open approach without the need to ligate the ipsilateral bladder pedicle. The entire ureterectomy and bladder cuff procedure is performed intracorporeally without the need for an added endoscopic procedure to resect the intramural ureter. A watertight closure of the bladder can be achieved limiting the need for prolonged pelvic drainage and obviating the need for a cystogram to evaluate for bladder extravasation prior to removing the bladder catheter.

Lymphadenectomy

The use of lymphadenectomy at the time of nephroureterectomy has not yet become standard practice despite data that indicates that this procedure may improve recurrence-free and overall survival (34). Currently, there is no prospective, randomized data available comparing nephroureterectomy with and without lymph node dissection. Formal node dissection templates according to tumor location (i.e., renal collecting system/proximal ureter, midureter, or distal ureter) have not been established. The motivation to perform a dedicated node dissection as a component of nephroureterectomy is to more accurately stage patients who may benefit from adjuvant therapy for node positive status and to remove micrometastatic disease to the benefit of patient oncologic outcomes. The arguments against lymphadenectomy include longer operative time required, added complication and morbidity, and unproven benefit of the procedure.

There are several studies that show the feasibility of lymphadenectomy during laparoscopic and robotic nephroureterectomy (26,35). Busby et al. (36) compared the outcomes of lymph node dissection at the time of open or laparoscopic nephroureterectomy and showed that the median node count was greater in the laparoscopic cohort (3 versus 6 nodes). In a matched comparison of robotic and laparoscopic nephroureterectomy, Ambani et al. (26) found that lymphadenectomy was more frequently performed (59% versus 27%) and the median node count in those patients in whom a node dissection was performed was greater (5.5 versus 1.0) during the robotic nephroureterectomy, indicating that the robotic approach may facilitate lymphadenectomy during this procedure (26). The findings from these studies are important because a greater number of nodes obtained may result in superior patient survival (37).

We advocate for a regional node dissection during minimally invasive nephroureterectomy. The region of dissection is dictated by the location of the tumor and the lymphatic drainage of that site. In the pelvis, the ureters drain to the internal, external, and common iliac lymph nodes. The mid-left ureter drains to the para-aortic nodes, whereas the mid-right ureter drains to the paracaval and interaortocaval lymph nodes. The renal pelvis and proximal ureter drain to the hilar and para-aortic (left) or paracaval (right) lymph nodes. Every effort should be made to remove the corresponding lymph nodes packets in their entirety instead of simply obtaining a node sample. Clips and monopolar and bipolar cautery used during the dissection preserve hemo- and lymphostasis.

PERIOPERATIVE CARE AND SURVEILLANCE

Regardless of minimally invasive approach, postoperative care is similar. We leave both a Foley catheter as well as a Jackson-Pratt drain in the pelvis following the surgery. In addition, local anesthesia with 50% lidocaine/50% Marcaine is injected subcutaneously into the extraction site incision to aid with postoperative pain. There is no gastric suction tube left in place. Patients are maintained on subcutaneous heparin and sequential compression devices in the perioperative period to avoid thromboembolic events, and gastrointestinal prophylaxis is administered while hospitalized. In addition, antibiotics covering skin flora are continued for 24 hours after surgery. Although we do use intravenous narcotics the night of surgery, patients are transitioned to oral narcotics once tolerating a clear liquid diet. Ketorolac is used for 24 to 48 hours in patients with sufficient glomerular filtration rate (GFR) (>60 mL per minute) after surgery. Oral acetaminophen is also used around the clock to reduce narcotic use.

Early ambulation is encouraged. Additionally, patients are placed on a clear liquid diet the night of their surgery, and the diet is advanced as tolerated on postoperative day 1. As long as patients are ambulating, tolerating a regular diet, and have adequate pain control, we typically discharge patients home on postoperative day 2 or 3. As long as there is no concern for urine leak, the drain is removed prior to discharge from the hospital.

Patients return to clinic 7 to 10 days after surgery for removal of the catheter and voiding trial. We do not typically obtain a cystogram prior to catheter removal, especially following robotic-assisted surgery where a precise two-layered closure can be achieved. Patients are given oral gram-negative antibiotic coverage immediately proceeding and for 2 days following catheter removal. In addition, male patients are initiated on tamsulosin or another alpha blocker 3 days prior to removal of the Foley catheter and for at least 1 week following removal. Patients who are unable to void are taught intermittent self-catheterization following surgery.

The surveillance schedule is dictated by the disease stage and grade. All patients with pathologic stage T3 or higher and/or positive lymph nodes are referred for consultation with medical oncology within 6 weeks of surgery for consideration of adjuvant chemotherapy. Most patient undergo a CT urogram (or MR urogram or noncontrasted CT) depending on GFR, chest X-ray, complete blood count, comprehensive metabolic panel, urine cytology, and cystoscopy every 6 months for the first 2 years and then annually up to 5 years with decreased use of imaging and cystoscopy at that point depending on the stage and grade of the disease. For low-grade tumors or high-grade noninvasive tumors, imaging and labs are performed at 6 months, 18 months, 36 months, 60 months, and then as needed; cystoscopy is performed every 6 months for the first year and then annually thereafter with a urine cytology at each cystoscopy visit. Cystoscopies for patients with carcinoma in situ on pathology follow the schedule for invasive disease but imaging and labs for noninvasive disease. The goal of surveillance is to identify disease recurrence in a timely fashion while reducing the morbidity of imaging and surveillance cystoscopy.

OUTCOMES

Nephroureterectomy remains the standard therapy for management of UTUC. There is a great deal of literature describing both the surgical and cancer control outcomes of patients undergoing minimally invasive nephroureterectomy. Several studies have shown comparable outcomes for minimally invasive approaches compared to open surgical management (38). In terms of minimally invasive approaches, the most robust data on outcomes is available for hand-assisted or conventional laparoscopic approaches with less data available for robotic-assisted outcomes. The few studies that have compared robotic approaches with other minimally invasive approaches have demonstrated comparable perioperative and short-term outcomes.

PERIOPERATIVE OUTCOMES

Several studies have compared perioperative outcomes for the various approaches to nephroureterectomy. Using the U.S. Nationwide Inpatient Sample, Hanna et al. (39) identified 7,401 and 754 patients undergoing open and laparoscopic nephroureterectomy, respectively, from 1998 to 2009. To adjust for potential differences, they used propensity score–based matching to compare perioperative results between the two approaches. There were no significant differences in patient age, race, gender, Charlson comorbidity index, hospital type, location, or procedure volume. Patients undergoing a laparoscopic approach were less likely to receive a blood transfusion (odds ratio [OR] 0.61; 95% confidence interval [CI] 0.47 to 0.79, P <.001), have an intraoperative complication (OR 0.43; 95% CI 0.26 to 0.73, P = .002), have a pulmonary complication (OR 0.44; 95% CI 0.24 to 0.80, P = .007), or have length of stay longer than 5 days (OR 0.43, 95% CI 0.36 to 0.51, P <.001). There were no statistical differences in other complications or in-hospital mortality (39).

In the only randomized study of the two approaches, 80 patients with localized UTUC were randomized to either open (flank and separate lower abdominal incision) or laparoscopic nephroureterectomy. The study was powered (90%) to detect a difference in mean time to discharge between the two groups (alpha of 0.05). However, it was not powered to detect a difference in other perioperative or oncologic outcomes. Patients were stratified by stage and age. There were no statistical differences in operative times between the two groups, but blood loss was significantly less with the laparoscopic approach (104 mL versus 430 mL, P <.001—no blood transfusions were necessary in either group) as was length of stay (2.3 versus 3.7 days, P <.001) (40).

In one of the few studies comparing laparoscopic versus robotic nephroureterectomy, Ambani and colleagues (26) identified 22 matched pairs from a single institutional cohort. They observed both had a significantly increased operative time (298 versus 251 minutes) and blood loss (380 mL versus 233 mL) for the robotic versus the laparoscopic approach with an associated higher rate for blood transfusion (9% versus 0%) with a similar rate of complication but increased use of lymph node dissection (26). Overall, the data suggests that minimally invasive approaches are associated with decreased morbidity compared to open nephroureterectomy, but further data is needed to evaluate the use of a robotic-assisted approach.

ONCOLOGIC OUTCOMES

Recurrence after nephroureterectomy can occur within the urinary tract, in the resection bed, or distantly. Most data on recurrence have focused on the open approach, but there are several series that have examined outcomes in patients undergoing laparoscopic or robotic-assisted nephroureterectomy. Most series report that approximately 30% to 40% of patients recur within their bladder. Several variables have been explored to understand this risk of recurrence. This includes the management of the distal ureter (resection with bladder cuff versus pluck technique) as well as early clipping of the ureter in cases of proximal and renal pelvis urothelial carcinoma. Most series have not demonstrated an increased risk of recurrence by bladder cuff approach. Xylinas (41) and the Upper Tract Urothelial Carcinoma Collaboration reported outcomes in 2,681 patients undergoing nephroureterectomy. Intravesical, extravesical, and endoscopic approach were performed in 68%, 29%, and 3% of patients, respectively. In a multivariable analysis, an endoscopic approach to the distal ureter, laparoscopic technique, prior bladder cancer, higher tumor stage, and associated carcinoma in situ (CIS) were all predictors of intravesical recurrence. This suggests that some aspect of the laparoscopic approach may increase the risk of tumor seeding to the bladder, but further data is needed to elucidate this (41).

One randomized controlled study evaluated the perioperative use of mitomycin in patients undergoing nephroureterectomy to prevent bladder recurrence. A total of 284 patients were randomized to a single intravesical dose of 40 mg of mitomycin versus standard care. Using a modified intent to treat analysis, 17% in the mitomycin arm and 27% in the standard care arm developed a recurrence at 1 year, with an absolute risk reduction of 11% and relative risk reduction of 40% with the number needed to treat to prevent one bladder recurrence being nine patients. No serious adverse events were reported but five patients could not tolerate instillation for the required hour (20). The Upper Tract Urothelial Carcinoma Collaboration built on this finding and developed a decision tool for both surveillance and possible use of mitomycin in the perioperative period. Their model included age, gender, tumor location, surgical technique, bladder cuff management, prior bladder cancer, stage, CIS, and lymph node status. If a cutoff of a 15% chance of recurrence at 2 years is used to determine treatment with mitomycin, then 23% of patients would be spared treatment with only 0.3% developing recurrence (41).

The risk of contralateral recurrence has been well described and is reported in the 2% to 4% range in a review of the SEER data. It is unlikely that the risk of contralateral recurrence is influenced by surgical approach but rather by the stage and grade of the disease (especially CIS), prior history of bladder cancer, and prior treatment with intravesical therapy. Although the risk is low, all patients should undergo surveillance of their upper urinary tract as described earlier. Similarly, there is no data that suggests that there is a difference in locoregional recurrence, development of metastatic disease, or disease-free and overall survival when comparing different surgical approaches to nephroureterectomy. This is again likely due to the fact that it is the grade and stage of the disease that is driving the natural history of upper tract urothelial cancer (42).

SUMMARY

UTUC is a rare entity. Although nephroureterectomy is the standard approach for the management of this disease, alternative approaches can be used in select individuals based on both the grade and stage of the disease as well as patient comorbidities. Minimally invasive approaches to nephroureterectomy include hand-assisted, laparoscopic, and robotic-assisted approaches. The choice of approach depends on the complexity of the procedure, patient comorbidities, as well as experience of the surgeon. Robotic-assisted approaches allow for a minimally invasive technique that replicates the benefits of an open surgical approach. The choice of bladder cuff management is influenced by location of the tumor as well as surgeon preference. An ideal approach ensures complete excision of the ureter with a bladder cuff and avoidance of tumor spillage. Although management of the bladder cuff and surgical approach may influence the risk of bladder recurrence, there is no data to suggest differences in oncologic outcomes with the various approaches to nephroureterectomy, whereas minimally invasive approaches decrease the morbidity of the procedure.

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CHAPTER 8 LAPAROSCOPIC RENAL PROCEDURES:RENAL CYSTECTOMY, BIOPSY, AND NEPHROPEXY

MICHAEL MADDOX AND BENJAMIN R. LEE

INTRODUCTION

Laparoscopic Management of Renal Cystic Disease

Simple cysts are a commonly encountered and often incidental finding on abdominal imaging studies. These are acquired lesions postulated to develop from diverticula of the distal convoluted tubule and collecting duct. Previous autopsy reports indicate that 50% of people older than age 50 years have renal cysts (1). With the advent and increased use of spiral computerized tomography (CT), more contemporary studies show an overall prevalence of 41% in the adult population with an increase to more than 60% by age 80 years (2).

DIAGNOSIS

Historically, the diagnosis of renal cysts was made by intravenous urography with tomography. However, ultrasound (US) and CT have supplanted intravenous urography as the primary diagnostic tools for renal cystic disease. Bosniak is credited with describing a spectrum of complexity to renal cystic lesions based on characteristics on abdominal CT. Magnetic resonance imaging (MRI), with its superior contrast resolution compared to CT, may help distinguish between benign and malignant complex cystic lesions. Further, since the introduction of the Bosniak classification of renal cysts, MRI has been validated as a surrogate for CT scan regarding the applicability of the Bosniak classification scheme (3).

The majority of renal cysts are asymptomatic and thus an incidental finding on imaging. However, a small subset of patients may present atypically with a palpable mass, obstructive symptoms, infections, or pain thought to be related to hemorrhage into the cyst or distension of the renal capsule. Cysts associated with autosomal dominant polycystic kidney disease (ADPKD) may manifest as hypertension or renal insufficiency.

BOSNIAK CLASSIFICATION

Prudent to any discussion of management of renal cystic disease is the Bosniak classification scheme. Distinguishing simple renal cysts from solid renal masses with cross-sectional imaging is not difficult. However, cystic lesions of the kidney are heterogeneous entities covering a wide spectrum from benign simple cysts to cystic renal cell carcinomas (RCCs). In fact, 5% to 7% of RCC are cystic, often demonstrating a slower growth rate and more favorable pathologic characteristics compared to solid RCC (4).

Bosniak (5) first described his classification of renal cysts in 1986, in which the lesion's morphology and enhancement characteristics were assessed and lesions were placed into four categories (I to IV) with increasing concern for malignancy. The consensus among urologists and radiologists is that Bosniak I cysts are simple cysts requiring no further follow-up with minimal risk of malignancy, whereas Bosniak IV cysts are complex and managed surgically as a presumed malignancy. However, there is considerable interobserver variability in distinguishing Bosniak II and Bosniak III lesions (6). Bosniak later modified the scheme to include a fifth category of Bosniak IIF to help narrow the gap between II and III renal cysts (7). The current classification is summarized in Table 8.1. CT images of the five Bosniak subclassifications are shown in Figure 8.1A–E.

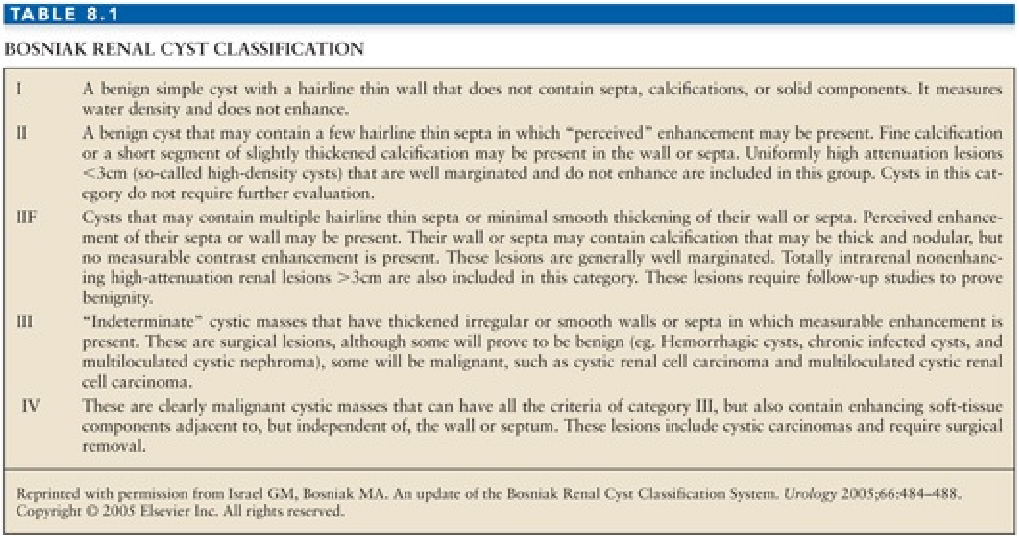

TABLE 8.1

BOSNIAK RENAL CYST CLASSIFICATION

I	A benign simple cyst with a hairline thin wall that does not contain septa, calcifications, or solid components. It measures water density and does not enhance.
II	A benign cyst that may contain a few hairline thin septa in which "perceived" enhancement may be present. Fine calcification or a short segment of slightly thickened calcification may be present in the wall or septa. Uniformly high attenuation lesions <3cm (so-called high-density cysts) that are well marginated and do not enhance are included in this group. Cysts in this category do not require further evaluation.
IIF	Cysts that may contain multiple hairline thin septa or minimal smooth thickening of their wall or septa. Perceived enhancement of their septa or wall may be present. Their wall or septa may contain calcification that may be thick and nodular, but no measurable contrast enhancement is present. These lesions are generally well marginated. Totally intrarenal nonenhancing high-attenuation renal lesions >3cm are also included in this category. These lesions require follow-up studies to prove benignity.
III	"Indeterminate" cystic masses that have thickened irregular or smooth walls or septa in which measurable enhancement is present. These are surgical lesions, although some will prove to be benign (eg. Hemorrhagic cysts, chronic infected cysts, and multiloculated cystic nephroma), some will be malignant, such as cystic renal cell carcinoma and multiloculated cystic renal cell carcinoma.
IV	These are clearly malignant cystic masses that can have all the criteria of category III, but also contain enhancing soft-tissue components adjacent to, but independent of, the wall or septum. These lesions include cystic carcinomas and require surgical removal.

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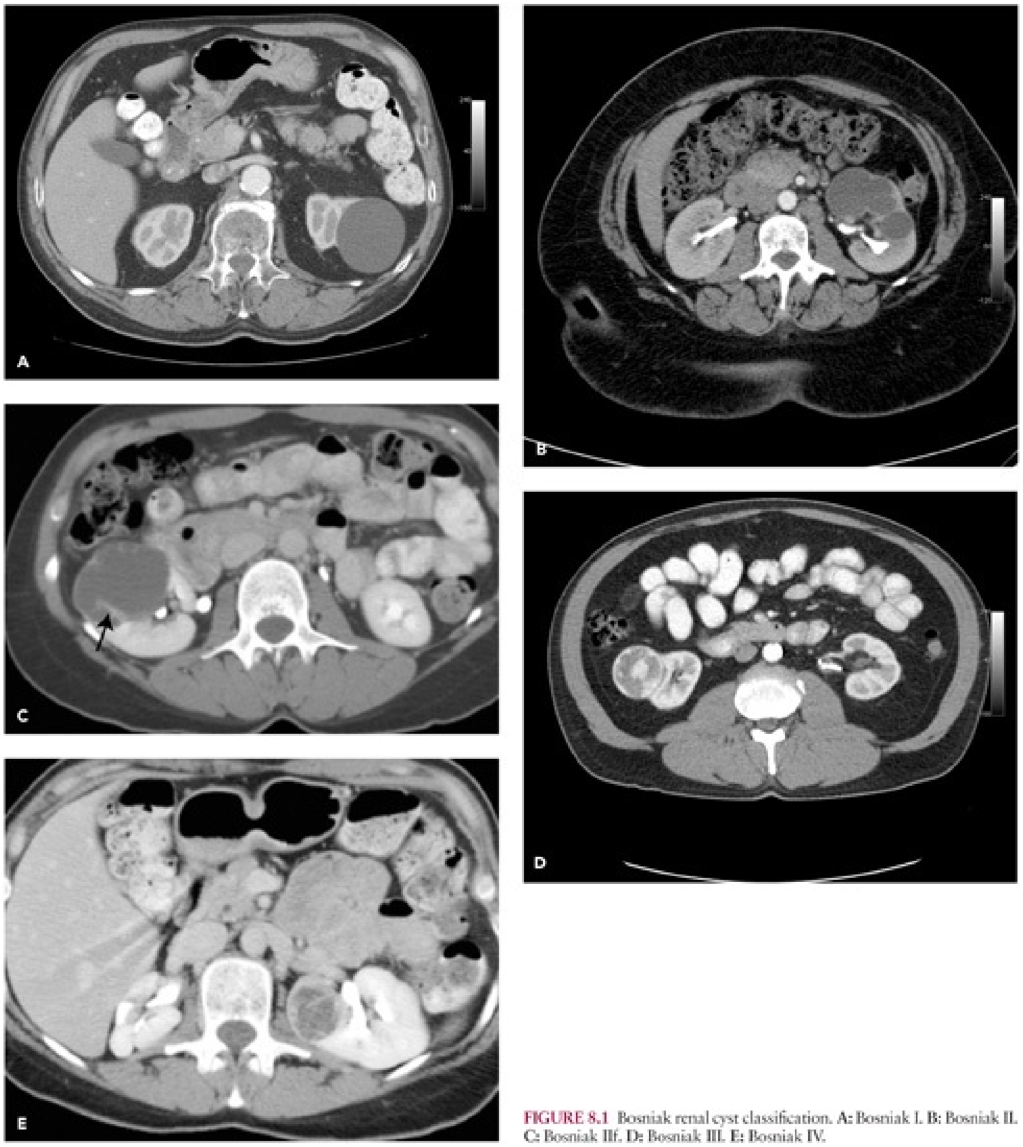

FIGURE 8.1 Bosniak renal cyst classification. A: Bosniak I. B: Bosniak II. C: Bosniak IIF. D: Bosniak III. E: Bosniak IV.

Malignancy Risk by Bosniak Class

The goal of the Bosniak classification was to provide a reproducible and universal description of cystic renal lesions in order to guide therapy. However, the majority of studies attempting to characterize pathologic outcomes by Bosniak classification are retrospective case series and limited by small patient numbers. In addition, preoperative attempts to assess the risk of malignancy based on cytologic evaluation of cyst fluid have not proven to be helpful with only 14% of known cystic RCC having a positive preoperative cytology (8).

A number of studies have quantified the malignancy risk of renal cystic lesions. These studies should be interpreted with some caution because many have used radiographic surveillance with stability of the lesion to define benignity. Koga et al. (9) pooled data from five studies including their own to assess the percentage of lesions that were ultimately malignant based on their CT Bosniak classification. All of these studies included used a pathologic correlate to the imaging findings. Malignancy rates were 2%, 27%, 60%, and 90% for Bosniak I, II, III, and IV, respectively (8–12).

It is important to understand that there is no absolute malignancy risk for all subclasses of renal cysts but rather a continuum in which the imaging characteristics should be interpreted in the context of the clinical situation on an individual patient basis.

SIMPLE CYSTS

It is generally agreed on that simple renal cysts (Bosniak I) are acquired lesions. These cysts are more common in men than women with an incidence ratio of approximately 1.4:1 (2). Terada et al. (13) demonstrated the propensity of these cysts to increase in size and quantity with age. With this progression, a subset of these patients will develop symptoms without other discernible etiologies on imaging. If these patients fail conservative measures with anti-inflammatory agents and narcotic analgesics, they may benefit from further intervention.

Some apply a percutaneous approach initially to assess for relief of symptoms with aspiration to demonstrate a causal relationship. Aspiration alone has shown a significant recurrence rate between 41% and 78% (14–16). Addition of a sclerosing agent at the time of percutaneous aspiration may improve recurrence rates, but these are still unacceptably high ranging between 32% and 100% (5,17). It should be mentioned as well that percutaneous sclerosing agents are contraindicated in parapelvic cysts due to the risk of injury to the collecting system.

Laparoscopic cyst decortication (LCD) offers a more definitive management of symptomatic simple cysts without the morbidity of open surgical decortication. Roberts et al. (18) reported their results of laparoscopic ablation of 32 patients, 11 with parapelvic, and 21 with parenchymal cysts. All patients were symptomatic at the time of intervention. They showed at a mean follow-up of 18.1 months, all patients were without symptom recurrence, and only one patient experienced a radiographic recurrence without symptoms. The complication rate was 13% with one major complication (ureteral stricture) and three minor complications (ileus, intraoperative diaphragm injury repaired without consequence, and a transient peroneal nerve palsy) (18).

In one of the largest series of LCD of simple renal cysts, Atug et al. (19) demonstrated a durable response at a mean follow-up of 58 months. Using pre- and postoperative patient-reported pain scales, the mean scores were 7.66 reduced to 1.21 following surgery. The 91.1% of patients were symptom-free, whereas four patients (8.8%) reported some alleviation of their symptoms. Radiographic success was 95.5% in this series with two of the partial responders developing asynchronous de novo cysts (19).

Okeke et al. (20) investigated their experience with LCD compared to sclerotherapy. At 17 months of follow-up, all patients undergoing decortication were without symptoms, whereas the sclerotherapy cohort had a 100% recurrence of symptoms (20). Laparoscopic cystectomy is proven to be a safe, efficacious, and durable treatment modality for patients with symptomatic simple renal cysts.

AUTOSOMAL DOMINANT POLYCYSTIC KIDNEY DISEASE

Although most simple cysts are sporadic/acquired, ADPKD invariably is responsible for a significant proportion of patients with symptomatic renal cysts. ADPKD affects between 300,000 and 600,000 Americans (21). It is the fourth most common cause of renal failure comprising approximately 10% of all dialysis patients (22). Enlarged cysts compress the renal parenchyma and vasculature, resulting in renal capsular distention and an ischemic activation of the renin-angiotensin-aldosterone system resulting in pain and hypertension (23,24). Therefore, a majority of these patients will become symptomatic and may ultimately require therapeutic intervention.

The urologic literature describing LCD for ADPKD is composed primarily of retrospective case series with many of them having a heterogeneous mix of patients with simple cysts and cysts as a result of ADPKD. We will review the largest series of patients undergoing laparoscopic management of exclusively ADPKD patients.

In a comprehensive review of all relevant series using LCD for ADPKD, Millar et al. (25) addressed the outcomes for pain, hypertension, and renal function. Despite the variable degree of improvement and duration, LCD consistently offers an improvement in chronic pain in the ADPKD population following LCD. Although some studies report an encouraging trend toward improvement in postoperative blood pressure, the literature does not consistently confirm the benefit of LCD for management of hypertension. Finally, the majority of patients can expect an insignificant change in postoperative renal function following LCD, but the authors caution that significant preoperative renal insufficiency may pose a greater risk of postoperative deterioration of renal function (25).

SURGICAL TECHNIQUE

Retroperitoneal Approach

Standard positioning and preparation are carried out with the patient in the flank position. Port placement is depicted in Figure 8.2.

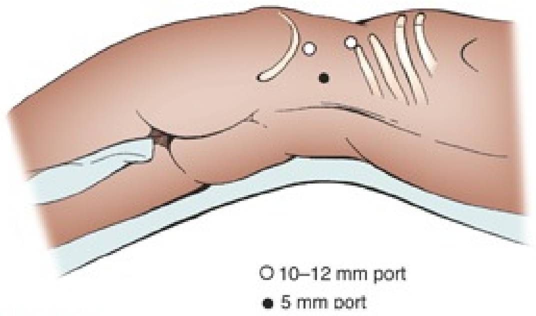

FIGURE 8.2 Port placement for retroperitoneoscopic kidney surgery, such as nephropexy, renal cystectomy, and biopsy.

A 1.5-cm incision is made at the tip of the 12th rib, and the dissection is carried down to the lumbodorsal fascia, which is then pierced with a tonsil clamp to enter the retroperitoneal space. Finger dissection is then performed along the psoas muscle to mobilize the posterolateral aspect of the kidney. A 10- to 12-mm visual balloon dissector trocar is then placed and the space is dilated. The dilating balloon is then removed and a blunt-tip trocar is placed. Pneumoretroperitoneum is established to 15 mm Hg, and a 5-mm trocar is placed in the posterior axillary line below the 12th rib. A third trocar is inserted approximately two fingerbreadths above the iliac crest in the anterior axillary line. Laparoscopic US may be used in cases where cysts are difficult to locate. An additional instrument for dissection and counter traction of large cysts can be placed via a 5-mm trocar midway between the iliac crest and the 12th rib in the posterior axillary line.

Once the cyst is exposed from beneath the perinephric fat, the fluid is aspirated and sent for cytology. A gallbladder needle or Orandi-type needle can be used to accomplish the aspiration. The free wall of the cyst is then excised with dissecting scissors, harmonic scalpel, or hook and sent for pathologic analysis. The wall should be incised as close to parenchyma as possible without entering the parenchyma. The parenchymal base of the cyst is then examined for evidence of neoplastic change using cup biopsy forceps to perform frozen-section analysis if there is clinical suspicion of carcinoma. The edges of the cyst are cauterized and hemostasis is verified after the pneumoretroperitoneum has been lowered to 5 mm Hg. The argon beam coagulator can be used to quickly paint over any raw bleeding surfaces of parenchyma or cyst wall. If the argon beam coagulator is used, care should be taken to vent the entering argon gas to prevent overpressure and barotrauma. Fibrin glue with or without oxidized cellulose can be applied for refractory areas of bleeding.

Transperitoneal Approach

The transperitoneal approach is ideal for treating anterior renal cysts, either simple or multiple. Under general anesthesia, with the patient in a 45-degree lateral flank position, pneumoperitoneum is established at the umbilicus. A 10-mm port is placed under laparoscopic visualization lateral to the umbilicus on the affected side in the lower quadrant. A third 5-mm trocar is placed in the midline halfway between the xiphoid process and umbilicus. A fourth trocar may be necessary for retraction in some cases and can be placed either in the lower midline or close to the xiphoid in the midline. The colon is reflected medially and the fascia of Gerota is incised. The perinephric fat around the cyst is dissected cleanly. In cases of polycystic disease, the kidney must be entirely mobilized inside the fascia of Gerota. Once again, the cyst fluid can be aspirated and sent for cytology. The cyst can then be unroofed as detailed earlier and its walls and base carefully inspected as seen in Figure 8.3. A portion of the cyst wall can be attached to the mobilized edge of peritoneum with either a clip or suture to ensure communication with the peritoneal cavity and decrease the likelihood of recurrence.

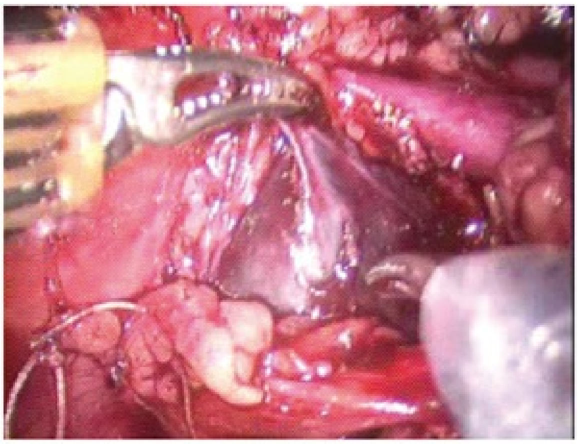

FIGURE 8.3 Transperitoneal laparoscopic cyst decortication.

If the cyst is extremely large, another technique is to fashion a window using dissecting scissors. Retroperitoneal fat or omentum can then be packed into the cyst, thus making it unnecessary to remove a large amount of cyst wall. If during any cyst unroofing, excision, or marsupialization there is concern for collecting system injury, indigo carmine can be administered intravenously or a preoperative ureteral catheter can be placed in complex cases for retrograde irrigation with methylene blue. This may be of particular use when approaching parapelvic cysts abutting the renal hilum.

Complications

Bleeding is always a possible complication of LCD. The argon beam coagulator and fibrin glue, or alternatively cauterization to the base, may help prevent this complication. It is imperative to ensure hemostasis with lowered abdominal pressures upon completion of the procedure.

Reaccumulation of cyst fluid is uncommon as previously indicated with the high radiographic success rates. Nieh and Bihrle (26) demonstrated that the use of fat was helpful in maintaining the patency of the marsupialization window. Other rare complications include prolonged ileus, delayed hemorrhage, urinary fistula, and nerve paresthesias.

CYSTIC RENAL MASSES/INDETERMINANT CYSTS

As previously indicated, with increasing complexity of renal cystic lesions, the risk of ultimate malignant pathology also increases. It is debated whether laparoscopic diagnostic or therapeutic intervention should be attempted in the treatment of Bosniak II and III cysts. This is largely due to the concern for tumor spillage with laparoscopic intervention, particularly for a transperitoneal approach with potential large field seeding. We review the available literature regarding these lesions.

There is a paucity of literature regarding laparoscopic decortication, biopsy, or extirpation for complex cystic masses. There are isolated case reports of significant tumor seeding following cyst decortication for eventually proven cystic RCC (27). However, Limb et al. (28) reported their experience with 57 patients with Bosniak II and III lesions undergoing laparoscopic intervention (28 Bosniak II and 29 Bosniak III). The cysts were aspirated and sent for cytology followed by biopsies of the cyst wall and base for immediate pathology.

Of the entire group, 11 patients ultimately were found to have a malignancy (3 patients/11% of Bosniak II, 8 patients/28% Bosniak III). Ten of the patients proceeded to nephrectomy during the same anesthetic: open partial (five), open radical (four), and laparoscopic radical (two). One patient underwent delayed nephrectomy due to a change in the pathology report postoperatively. There were no recurrences noted during the follow-up period at a mean of 40 months. The authors suggest the risk of tumor seeding may be overstated in the literature and suggest an initial diagnostic evaluation of indeterminate lesions may obviate the need for surgery in many patients with Bosniak II or Bosniak III cystic lesions (28).

Although the risk of tumor seeding in laparoscopic surgery for urologic malignancy is low, some physiologic consequences of laparoscopy deserve mention. Laparoscopy with CO_2 insufflation results in immunologic alterations that may result in increased risk of tumor seeding. Specifically, Ost et al. (29) demonstrated that the peritoneal immunologic response is blunted during laparoscopy with decreased monocytes and macrophages their cytokine release (interleukin-1 and tumor necrosis factor alpha). This may have implications regarding the host cellular immune response to shedding of malignant cells. Preclinical studies demonstrated sterile water irrigation in the peritoneal cavity and port sites prevented port site metastasis (30). Lee et al. (31) reviewed and suggest potential preventive measures when performing laparoscopy for urologic malignancy as seen in Table 8.2.

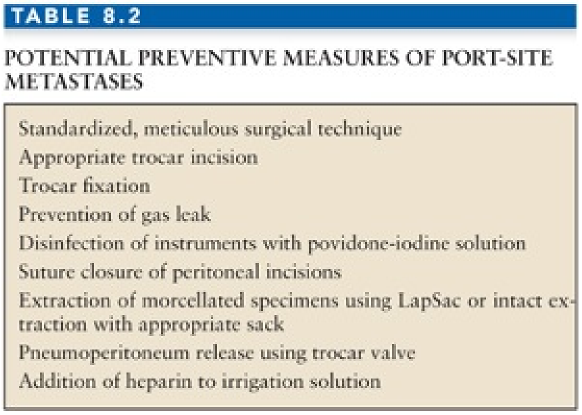

TABLE 8.2

POTENTIAL PREVENTIVE MEASURES OF PORT-SITE METASTASES

Standardized, meticulous surgical technique
Appropriate trocar incision
Trocar fixation
Prevention of gas leak
Disinfection of instruments with povidone-iodine solution
Suture closure of peritoneal incisions
Extraction of morcellated specimens using LapSac or intact extraction with appropriate sack
Pneumoperitoneum release using trocar valve
Addition of heparin to irrigation solution

Spaliviero et al. (32) performed the largest series of LPN for cystic renal masses. In this series, 50 patients with complex cystic masses (Bosniak II-9, IIF-4, III-12, IV-21) underwent LPN and were compared to 50 matched consecutive patients with solid renal masses. LPN was technically feasible in all patients without tumor spillage, and malignancy was confirmed in 22%, 25%, 50%, and 90% of the Bosniak II, IIF, III, and IV lesions, respectively. With a mean follow-up of 14 months, there has been one episode of recurrence in the cystic mass cohort compared to none in the solid mass group (32).

Although there is limited experience reported in the literature regarding definitive laparoscopic management of complex or indeterminate cystic masses, there are known advantages to laparoscopic intervention compared to open in renal surgery and one may expect an increased use of minimally invasive modalities in the treatment of this population.

RENAL BIOPSY

Percutaneous Biopsy

An evolving application of renal biopsy is focused on distinguishing between benign and malignant renal lesions. Biopsy is standard in patients suspected of lymphoma or with known secondary extrarenal malignancies. Further, with the increasing diagnosis of the small renal mass (SRM) as well as the use of percutaneous ablative therapies for SRMs, renal biopsy may occupy an important role in this growing subset of patients.

A general reluctance to the adoption of renal biopsy in clinical practice centers on complications, inaccuracy, or inadequacy of biopsy to detect malignancy as well as the risk of tumor seeding. We will address each of these issues with a review of the relevant literature.

The diagnostic accuracy of percutaneous image-guided renal biopsy for the detection of malignancy ranges between 85% and 100%, with the majority of recent studies exceeding a pathologic concordance accuracy of greater than 90% (33). Improved technique and experience with percutaneous biopsy may contribute to the reported increase in accuracy. Specifically, the use of a coaxial guide or cannula significantly increased the biopsy success rate by 15% without increasing complications (34).

Fine needle aspirate (FNA), defined by a 21-gauge or smaller needle, and core needle biopsies are two general categories of needle biopsy. FNA success is dependent on an experienced cytopathologist. FNA is generally thought to have a lower sensitivity for detecting malignancy compared to core biopsies, but the sensitivities range from 76% to 97% in recent series (35–39). In a large contemporary series of FNA of renal lesions, Andonian et al. (39) characterized nondiagnostic FNAs to be due to misdiagnosis in 2%, sampling error in 0.8%, and technical failure (defined as obtaining insufficient cellularity) in 16%. In another study, the diagnostic yield of FNA is considerably higher in adequate specimens compared to inadequate specimens (96.5% versus 41%). The authors also demonstrated a lack of correlation between the number of needle passes performed during FNA of renal lesions and the adequacy of the specimen (40). This emphasizes the importance of having the cytopathologist present at the time of FNA in order to ensure the adequacy of the specimen obtained.

To maximize the success of renal biopsy, both core biopsies and FNA should be used in conjunction when feasible (41,42). This is especially true in the diagnostic evaluation of complex cystic lesions in which the combination of techniques significantly increases the yield. Wunderlich et al. (43) demonstrated that biopsies of larger renal masses (performed ex vivo in their study) should be targeted toward the periphery of the tumor due to the increased propensity toward central tumor necrosis in lesions greater than 4 cm. Important to note is that FNA should be performed prior to any core biopsy in order to minimize the contamination with blood of the FNA specimen. Although FNA may offer the theoretical advantage of decreased complications as a result of the smaller needle gauge, this has not consistently been demonstrated.

Tumor seeding is the most controversial risk associated with renal biopsy. However, Volpe et al. (33) reviewed the literature and found only six case reports in total of this phenomenon, representing an overall risk of less than 0.01%. The use of guiding cannulas minimizes the potential for contact of malignant tissue with the biopsy tract. The risk of urothelial carcinoma tumor seeding may exceed the rates in nonurothelial renal malignancies, and caution should be exercised when performing biopsies of a potential urothelial cancer.

Other reported complications of renal biopsy include hemorrhage, arteriovenous fistula, infection, and pneumothorax. Approximately 44% of patients undergoing percutaneous needle biopsy will have evidence on CT of mild perirenal or subcapsular hematomas (44). However, clinically significant bleeding is rare and usually self-limiting according to contemporary percutaneous biopsy series (37).

Studies of small renal masses having pathologic data after radical or partial nephrectomy indicate approximately one-third of these patients will have a benign tumor (45–48). Further, the majority of patients diagnosed with SRMs are between 70 and 89 years of age. This population may benefit most from conservative treatment or observation alone for SRM. This has contributed to the controversy surrounding the role for preoperative renal biopsy. In addition, up to 39% of those patients with indeterminate cystic lesions (Bosniak III) may avoid unnecessary surgery with the use of preoperative renal biopsy (48).

Laparoscopic Biopsy

The majority of renal biopsies, independent of the indication, are performed percutaneously with image guidance. Real-time CT imaging has further increased the disparity between the percutaneous and laparoscopic or open approach. However, some clinical circumstances such as severe hypertension, bleeding diathesis, anticoagulation, morbid obesity, refusal of blood transfusions, and difficult renal anatomy dictate the use of more controlled access and better visualization of the kidney during biopsy. Hence, laparoscopic renal biopsy can be of great clinical value for some patients.

Adequate tissue samples are obtained in 96% to 100% of patients in the largest reported series. The majority of these patients are discharged from the hospital within 24 hours of the procedure. Complications directly related to the procedure are infrequent due to the ability to obtain hemostasis intraoperatively. Delayed bleeding is reported in 3% to 4% of patients and often is associated with coagulopathies and anticoagulants as a result of the population requiring laparoscopic biopsy (49,50). Arteriovenous fistula formation is not a concern due to the more superficial cortex sampled with laparoscopy and the avoidance of deeper, more significant renal vasculature.

Surgical Technique

Preoperative US, CT, or MRI can help characterize the kidney and better identify its location to adjacent structures during surgery. The procedure is ideally performed through a retroperitoneal approach. Patient preparation and positioning are identical to that described for laparoscopic retroperitoneal cystectomy. However, in many cases, only a camera port and single instrument port are necessary. Minimal blunt dissection through the perinephric fat to expose the lower pole of the kidney is then performed. Laparoscopic US may be necessary in some cases to identify the lower pole of the kidney. Cold-cup biopsy forceps or spoon forceps are used to obtain several samples of tissue, and these are sent to the pathologist for frozen-section analysis to confirm adequate tissue sampling.

This is depicted in Figure 8.4. A large-core Tru-Cut–type biopsy needle can also be passed through a trocar or percutaneously to obtain the sample.

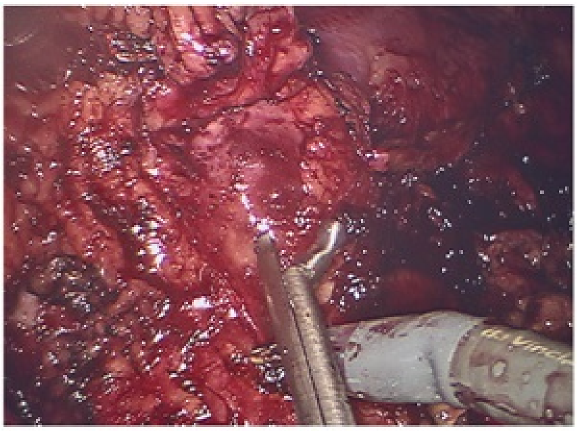

FIGURE 8.4 Renal biopsy using 5mm laparoscopic cup forceps.

Hemostasis can be achieved with electrocautery or an argon beam coagulator, and if necessary, the sites can be packed with oxidized cellulose. The retroperitoneal pressure should be lowered to 5 mm Hg and the biopsy sites and dissected space examined for hemostasis.

LAPAROSCOPIC NEPHROPEXY

Nephroptosis is a condition of great historical interest. It is classically defined as descent of the kidney >5 cm (or two vertebral bodies) when moving from supine to upright positions. The condition is much more common in female patients and more commonly affects the right kidney, but it can be bilateral in up to 20% of cases. Most affected patients are thin women and may be attributed to significant and rapid weight loss. Nephroptosis may be an incidental finding and should be treated only when associated with symptoms. Pain is believed to be a result of acute obstruction and/or renal ischemia upon standing due to the hypermobile kidney.

Diagnosis

Currently, many diagnostic modalities are available to establish the diagnosis. An intravenous pyeloplasty with the patient in the supine and standing position may be a useful initial test. The hypermobile kidney will descend in the upright position and may become hydronephrotic. Color Doppler US with measurement of resistive indices (RIs) in the supine and upright position may be helpful. A reduction in RI may be seen when moving from supine to upright, signifying a decrease in renal perfusion (51). Finally, a nuclear scan in the sitting position is useful in detecting an obstructive pattern after renal descent in addition to diminished blood flow to the kidney when the patient is erect. However, nuclear scan imaging systems are not uniformly capable in the upright position, and therefore, the availability of this diagnostic modality may be limited.

Surgical Technique

The surgical management of nephroptosis is controversial and variable. Many historical options exist, ranging from pexy and slings to other organs, ligaments, or the 12th rib. Current techniques usually employ suture fixation to the psoas and/or quadratus lumborum fascia. In general, the techniques require complete mobilization of the kidney inside the fascia of Gerota down to the renal capsule, with sutures placed directly through the fascia.

A transperitoneal approach is the most commonly reported access. The patient is positioned in full flank position, unless performing bilateral nephropexy, in which the patient is positioned supine and the bed tilted side to side to access each kidney. A three-port midline approach is most often used. The kidney is completely mobilized inside the fascia of Gerota and the fascia of the psoas muscle is identified. The operating table is then moved to a head-down position, which causes the mobile kidney to be positioned as cephalad as possible. Beginning at the upper pole, three interrupted nonabsorbable 3-0 sutures are then placed along the lateral margin of the kidney (upper, middle, and lower) through the renal capsule and then through the psoas fascia as seen in Figure 8.5. Care should be taken not to place the sutures too deeply into the renal parenchyma to prevent bleeding. In addition, the genitofemoral nerve running along the psoas fascia should be identified and avoided with placement of the sutures. Intracorporeal suturing can be simplified by the use of LAPRA-TY clips (Ethicon Endo-Surgery, Cincinnati, Ohio) to secure the sutures.

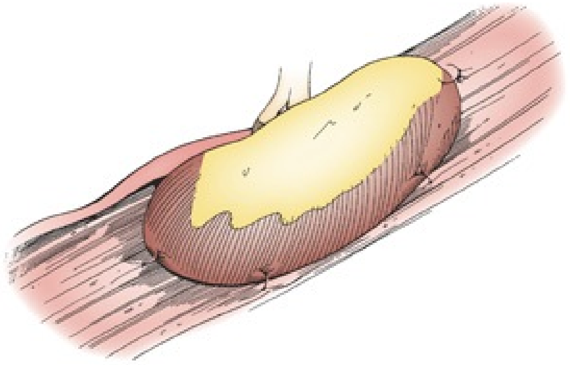

FIGURE 8.5 Nonabsorbable sutures placed through renal capsule and then psoas fascia on upper pole of kidney (medially, superiorly, and laterally).

The retroperitoneal laparoscopic approach provides a direct route to the kidney and may be useful in patients with a history of previous intra-abdominal surgery. However, the working space may be limited, making complete kidney mobilization difficult. Creation of the retroperitoneal space is performed as previously described, and nephropexy proceeds as per the transperitoneal approach. The procedure can be performed on an outpatient basis or under 24-hour observation. Follow-up supine and erect studies are generally performed in 6 to 12 weeks.

OUTCOMES

Success rates are quite high for laparoscopic nephropexy and are comparable to historical open series. Resolution of symptoms occurred in 80% to 100% of patients in the literature of laparoscopic nephropexy (52–54). Correlation of resolution of symptoms with resolution of renal descent on postoperative imaging appears to be high. In one series of 31 retroperitoneoscopic nephropexies, complete symptom resolution was present in 83% of patients, and 87% of patients had no evidence of persistent renal descent on postoperative radiography (55).

The most feared complication is failure to resolve symptoms. However, as noted earlier, failure is uncommon. Other complications include bleeding from the renal parenchyma and postoperative ileus, although they are uncommon.

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CHAPTER 9 LAPAROSCOPIC ABLATION OF SMALL RENAL MASSES

DANIEL RAMIREZ AND JEFFREY A. CADEDDU

The pervasiveness of cross-sectional abdominal imaging over the last decade has substantially increased the rate of incidentally diagnosed small renal masses (SRMs). This trend has impelled minimally invasive urologists to examine alternatives to complex extirpative surgical treatments. Cryotherapy and radiofrequency ablation (RFA) were initially described over a decade ago (1,2) with maturation of large, long-term series with these ablative techniques now available. Unfortunately, there currently exist no randomized controlled trials comparing ablative techniques with surgery or active surveillance. Available evidence has largely been mined from retrospective cohort reviews and case series. Ablative treatment particularly offers some advantages over partial nephrectomy, including decreased convalescence and improved preservation of renal function. Comparative studies have shown ablative techniques to have decreased blood loss, decreased length of stay, lower complication rates, and superior renal preservation when compared to partial nephrectomy (3–5). Traditionally, ablation has been reserved for older patients who are poor candidates for surgery or those patients who require maximal preservation of renal function. With oncologic outcomes and treatment efficacy of RFA and cryotherapy nearing that of surgical extirpation, many academic hospitals are now offering ablative techniques as first-line treatments for SRMs in the young and healthy patient. This chapter will focus on the rational and indications for renal ablative therapy with specific emphasis on a laparoscopic approach to applying RFA and cryotherapy for the treatment of SRMs.

INDICATIONS FOR LAPAROSCOPIC APPROACH

Ablation of SRMs, in general, is largely reserved for tumors measuring less than 4 cm in size. The authors of this chapter typically reserve ablation for tumors measuring less than 3.5 cm because oncologic efficacy is inferior for tumors larger than this size (6). Historically, ablative therapy has also been reserved for patients with limited renal functional capacity, bilateral or multiple masses, and patients with genetically inherited renal cell carcinoma (RCC) syndromes requiring management of multiple metachronous or synchronous lesions. Typically, ablative therapy for SRMs has been employed via a percutaneous technique because it minimizes morbidity. Nevertheless, there are specific instances where a percutaneous approach may not be feasible or is too dangerous to pursue. A laparoscopic approach is indicated when there is a necessity to physically mobilize critical structures away from the area of ablation and to allow for direct visualization of the ablated area in relation to other structures. For these reasons, the rate of intraoperative complications during laparoscopic ablative treatment of SRMs is low (7–11). A laparoscopic approach is usually indicated for masses in an anterior or lateral location because this is where many vital structures converge and where percutaneous probes cannot reach. Posterior tumors can generally be treated percutaneously, although a retroperitoneal laparoscopic approach may also be applied.

The only absolute contraindication to laparoscopic ablation of SRMs is irreversible coagulopathy. Relative contraindications include inability to tolerate insufflation necessary for laparoscopic abdominal surgery, tumors with cystic components, large diameters, and close approximation to hilar structures. Ablation of endophytic renal lesions not seen on ultrasound preoperatively should not be attempted via a laparoscopic approach because identification of the mass is dependent on the surgeon’s ability to identify it on intraoperative ultrasonic imaging.

MECHANISMS OF ACTION OF ABLATIVE THERAPIES

Cryotherapy

Cryoablation is the most studied ablative procedure for renal masses and was first described in canine models in 1994 by Uchida et al. (12). Since that time, cryoablation techniques have improved with the introduction of small probes and use of argon and helium gas, enhancing the accuracy of the freeze-thaw cycle. The smallest available probes needles are 17-gauge (1.47 mm) in size (Endocare, Irvine, California).

Once probe placement is confirmed on intraoperative imaging, argon gas is rapidly injected through the tip of the needle which briskly creates an ice ball. Once the freezing cycle is complete, pressurized helium is then forced through the needle probe to induce thawing. This precipitous freezing of renal tissue results in extracellular and intracellular ice crystal formation leading to acute intracellular pH changes, protein denaturation, decreased intracellular osmotic concentration, and immediate physical mechanical destruction of the cellular membrane (13). Injury to vascular endothelium is also exhibited which results in demonstrable microvascular thrombosis and ischemia leading to delayed necrosis over hours and days after treatment. Freeze-thaw cycles reliably and reproducibly cause necrosis of renal parenchyma at temperatures at or below −19.4°C (14). Malignant lesions may require even lower temperatures to result in cellular death, thus most clinical protocols call for freezing temperature of −40.0°C (15). Experimental models have demonstrated that ice balls produced via cryotherapy only reach these extreme temperature 3.1 mm within their inner edge (16). Because of this, the ice ball is allowed to extend 5 to 10 mm beyond the boundary of the renal lesion in clinical practice.

Ice ball size and temperature monitoring are verified with intraoperative imaging (computerized tomography [CT], magnetic resonance imaging [MRI], or ultrasound [US]) and thermocouples found at the end of the ablation probes. The majority of large clinical series describing outcomes of cryoablative treatments of SRMs use a double freeze-thaw cycle to ensure cellular death. This has been shown to increase oncologic efficacy compared to single-cycle protocols (17).

Radiofrequency Ablation

The mechanism of RFA relies on the transformation of high-frequency electromagnetic waves into heat causing thermal damage. The increase in temperature is not applied directly by the probe. An alternating monopolar current is passed from the electrode in to the target lesion, resulting in ionic disturbance and molecular friction which, in turn, causes a release of energy as heat (18). This increase in thermal energy results in permanent protein denaturation and desiccation which occurs instantly at a temperature greater than 60°C (19). These extreme temperatures also lead to breakdown of cell membrane, nuclear instability, microvascular thrombosis, and, ultimately, ischemia and necrosis of target tissue (20). The currently available platforms for RFA differ in the manner in which they modulate energy delivery. Temperature-based feedback inhibition (AngioDynamics, Latham, New York) measures the temperature at the edge of the ablation field in order to avoid overheating. Impedance-based feedback inhibition (RF 3000, Boston Scientific, Natick, Massachusetts; Cool-tip, Covidien, Mansfield, Massachusetts) reduces delivered current by sensing the increased resistance in target tissue. These feedback inhibition mechanisms reduce the production of charred tissue, thus improving efficacy and maintains the size of the ablation zone.

Concurrent intraprocedure monitoring of the lesion with CT, US, or MRI is problematic due to the production of microbubbles and poor innate delineation on imaging between normal renal parenchyma and tissue ablated via RFA (21). However, real-time imaging may be unwarranted as the efficacy of RFA is determined by the deployment diameter of the probe tines and maximum temperature reached. In contrast to the ice ball seen in cryoablation, the size of the lesion does not grow with increased activation time beyond the minimum threshold.

SURGICAL TECHNIQUE AND POSTOPERATIVE CARE

Perioperative Preparation and Considerations

Careful assessment of the patient’s past surgical history and evaluation of cross-sectional imaging should be performed in each case to identify the best surgical candidate for laparoscopic ablation. Appropriate consent should be obtained from the patient after the risks and benefits of ablation and other alternative procedures are discussed in detail. A transperitoneal approach is employed for superior and anterior renal masses. A retroperitoneal method may be considered for posterior and lateral tumors when a percutaneous technique is not possible. Renal ultrasound should also be performed on masses that are found to be endophytic on cross-sectional imaging in order to assess whether intraoperative ultrasonic evaluation can be successfully performed. Completely endophytic masses that are not seen on preoperative renal ultrasound should not be treated with laparoscopic ablation as intraoperative identification may not be feasible.

Positioning, Port Placement, and Operative Technique for Exposure of the Tumor

Once the patient is bought to the surgical theater, a Foley catheter is placed to ensure complete decompression of the bladder and the patient is appropriately positioned. For a transperitoneal approach, the patient is placed in a modified flank position. A standard flank position is applied when a retroperitoneal approach is proposed.

Abdominal insufflation may be obtained with a Veress needle or with open placement of a Hasson trocar. For a transperitoneal approach, three laparoscopic ports are inserted in the same arrangement as for transperitoneal laparoscopic nephrectomy. For a retroperitoneal approach, access to the retroperitoneum is achieved with the use of a visual obturator trocar or by an open method with the placement of an index finger through a small incision overlying the tip of the 12th rib in order to develop the retroperitoneal plane between the peritoneum and psoas muscle. The retroperitoneal space can further be developed with the use of a space-expanding dilation balloon or with laparoscopic development.

Once intraperitoneal access is obtained, exposure of the renal mass is achieve initially by incising the white line of Toldt in order to medially reflect the colon off of Gerota fascia. The ureter and gonadal vessel should be identified in order to ensure preservation and limit injury. The renal hilum should also be identified in order to facilitate control of main renal arterial supply in the case that uncontrollable renal hemorrhage is encountered during ablation because this could be a life-saving maneuver. Once the kidney is visualized, Gerota fascia is opened and the tumor exposed by careful dissection and removal of perinephric adipose tissue. The opposite side of the kidney should also be exposed in cryoablation cases to allow for ultrasonic monitoring of probe placement and to visualize the tumor margins at time of ablation. This is especially vital in treatment of tumors that are found to be completely endophytic.

Laparoscopic Radiofrequency Ablation

Once the kidney is exposed and the lesion is exposed, a location on the abdominal wall should be identified to permit entry of the RFA probe to the tumor at a right angle to its most exophytic juncture (Fig. 9.1). We prefer to use the temperature-based system which will be described herein. Once the probe is inserted, the tines are opened and allowed to spread to a diameter encompassing 5 to 10 mm outside the tumor margin in order to ensure complete ablation. Ablation with radiofrequency energy is performed in two cycles to a target temperature of 105°C. The length of each cycle is determined by the size of the tumor (Table 9.1). After ablation is concluded, the probe is carefully separated from the tumor and an incisional biopsy is performed. Biopsy of the tumor after completing RFA minimizes the risk of bleeding and potential seeding of the tumor. A study from our institution demonstrates that histologic architecture is maintained in the tissue sufficient for diagnosis after RFA is performed (22). The site of biopsy is evaluated for hemostasis. Application of hemostatic agent may be applied at this point as needed for mild bleeding. When bleeding is not controlled with use of hemostatic agents alone, electrocautery or argon beam coagulation may be use.

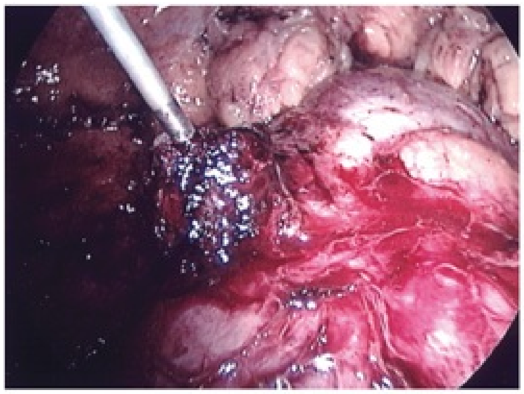

FIGURE 9.1 Example of single RFA probe near of ablation cycle with evident tissue dessication.

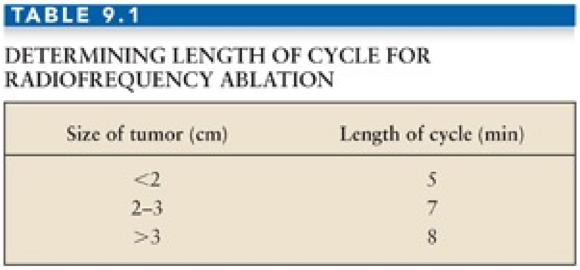

TABLE 9.1

DETERMINING LENGTH OF CYCLE FOR RADIOFREQUENCY ABLATION

Size of tumor (cm)	Length of cycle (min)
<2	5
2–3	7
>3	8

Once ablation is complete and hemostasis is maintained, Gerota fascia is reapproximated with the use of Weck Hem-O-Lok clips (Teleflex, Research Triangle Park, North Carolina) in order to place the kidney back into a retroperitoneal position. The colon is placed back in its anatomic location and the trocars are removed under direct vision to ensure hemostasis.

Laparoscopic Cryoablation

Once the tumor is identified and margins are demarcated, core needle biopsies are obtained prior to ablation. The biopsy needle should be passed through a laparoscopic trocar in order to avoid the hypothetical risk of seeding. Central placement of a single 4.8 mm cryoablation probe can be used to treat tumor 2 cm or less in diameter. For tumor greater than 2 cm in diameter, ablation can be accomplished with the use of three 17-gauge (1.47 mm) probes placed in a triangulated fashion within the lesion to ensure the formation of the ice ball extends beyond the tumor margin. Two freeze-thaw cycles are employed for completion of cryoablation, as discussed previously. Ice ball formation is monitored continuously via laparoscopic ultrasonography and under direct vision (Fig. 9.2). Intraoperative temperature monitoring can be accomplished with the use of 18-gauge thermocouple placed at the tumor margin. Temperatures below −20°C must be achieved in order to ensure cellular death. Once both freeze-thaw cycles are complete, the probes are removed and hemostatic agents applied to puncture sites as needed. It is paramount that the second thaw cycle is complete prior to removal of the cryoprobes in order to avoid cracking of the lesion that can lead to hemorrhage.

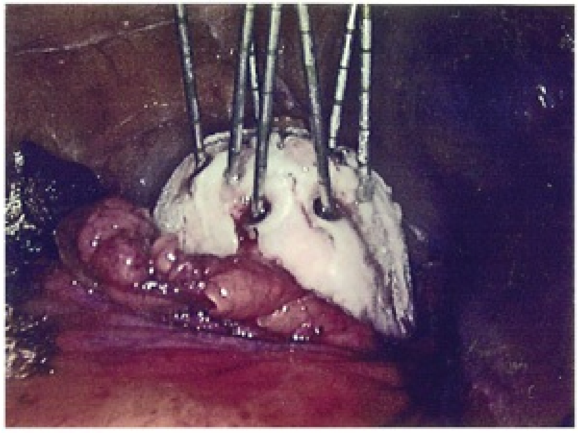

FIGURE 9.2. Example of multiple cryoablation probes with ice ball enveloping tumor.

Postoperative Care

Postoperative care is similar to laparoscopic nephrectomy. Hematocrit should be assessed and deemed stable prior to discharge home. The patient may be admitted for standard care on the floor and allowed to have their diet advanced as tolerated. Patients should be ambulating, passing flatus, and tolerating a regular diet prior to discharge. This is frequently accomplished by the first postoperative day.

COMPLICATIONS

Complications of Cryotherapy

The most common complications associated with laparoscopic cryoablation include intraoperative hemorrhage, delayed perinephric hematoma, infection, hematuria, flank pain, paresthesia, and urinary tract infection. A recent study by Cestari et al. (23) reviewed 104 cases of laparoscopic cryoablation and only reported three major complications, including hematoma requiring transfusion, perinephric abscess requiring CT-guided drain placement, and ureteropelvic junction (UPJ) obstruction requiring open pyeloplasty. Lehman et al. (24) performed a retrospective review of 44 patients with 51 tumors who underwent laparoscopic cryoablation for SRMs. The patients were divided into two cohorts: 23 patients with 30 masses <3 cm in size (mean size 1.8 cm) and 21 patients with 21 masses ≥3 cm in size (mean size 4.0 cm). The first group with smaller renal masses suffered no complications, whereas the second group with masses larger than 3 cm had a complication rate of 62% including two fatalities. The most common complication in this series was postoperative hemorrhage requiring transfusion (38%).

In regard to percutaneous versus laparoscopic cryoablation, Johnson et al. (25) reviewed 139 cases of cryoablation and described a total of 20 complications (16 after a percutaneous approach, 4 after a laparoscopic approach) for an overall rate of 14.4%. The two major Clavien 3b complications reported included one significant retroperitoneal hemorrhage requiring open exploration after percutaneous cryoablation, and one case that were converted to open partial nephrectomy when the mass was found to be inaccessible via laparoscopic approach. The minor complications in this series included 10 patients with postprocedure flank pain, 2 with urinary tract infections, 1 with small hematoma, 1 with persistently elevated serum creatinine, and 1 with postoperative pneumonia. Finley et al. (26) performed a retrospective review comparing outcomes between percutaneous and laparoscopic cryoablation. The reported rate of transfusion was 11.1% and 27.8%, respectively. A laparoscopic approach was associated with a significantly longer operative time (147 versus 250 minutes) as well as a longer hospital stay (1.3 versus 3.1 days). Overall complication rate was higher in the laparoscopic group (40%) versus the percutaneous group (22%).

Complications of Radiofrequency Ablation

The most common serious complications associated with RFA include urinoma, UPJ obstruction, and probe site pain. A study by Johnson and Cadeddu (27) in 2004 reviewed 133 patients who underwent RFA and found an overall complication rate of 7.6%, three major complications and seven minor. All three major complications were found in the group that underwent laparoscopic RFA and involved urinoma requiring ureteral stent placement, UPJ obstruction requiring open pyeloplasty, and postoperative ileus. In 2007, Zagoria et al. (28) described two cases of proximal ureteral strictures from a series of 73 SRMs treated with RFA. A recent study out of our institution reviewed 111 SRMs treated via laparoscopic RFA and found an overall complication rate of 8.8% (*n* = 7) (11). Of those complications, four were minor (Clavien 1–2) and three were major (Clavien 3b). Of the major complications, two patients suffered UPJ obstruction requiring repeat surgery and one patient with urine leak requiring stent placement.

A recent meta-analysis comparing cryoablation and RFA found no difference in the rate of complication between the two modalities (29). They found a pooled overall complication rate of 19.9% in the cryoablation group (19 studies, 431 cases) and a pooled complication rate of 19.0% of the RFA group (11 studies, 426 cases). A comparison of complications between cryoablation and RFA can be found in Table 9.2.

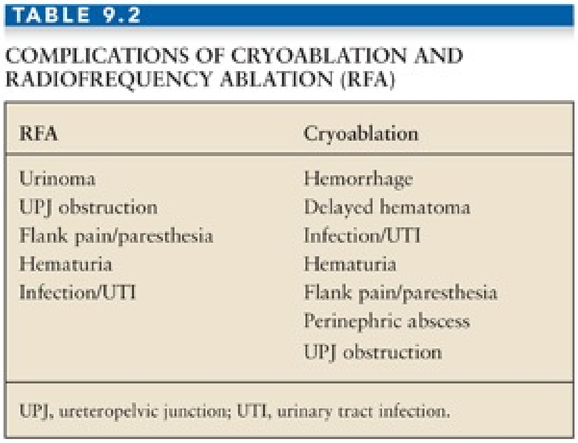

TABLE 9.2

COMPLICATIONS OF CRYOABLATION AND RADIOFREQUENCY ABLATION (RFA)

RFA	Cryoablation
Urinoma	Hemorrhage
UPJ obstruction	Delayed hematoma
Flank pain/paresthesia	Infection/UTI
Hematuria	Hematuria
Infection/UTI	Flank pain/paresthesia
	Perinephric abscess
	UPJ obstruction

UPJ, ureteropelvic junction; UTI, urinary tract infection.

ONCOLOGIC OUTCOMES

Outcomes after Cryoablation

Among the studies reviewing the 5-year oncologic outcomes for cryoablation of SRMs, long-term disease-free survival rates are 80% and higher with reported cancer-specific survival of 90% or greater. A study by Guazzoni (30) in 2010 reviewed 44 patients who underwent percutaneous cryoablation of SRMs with a mean follow-up of 61.3 months. They reported one case of local recurrence, 100% disease-specific survival, and 93.2% overall survival. In 2007, Weld et al. (31) published a series of 31 patients with a mean follow-up of 46 months and reported a 100% disease-specific survival and only one case of local recurrence. Only 22 patients in the study had biopsy confirmed malignancy. The series with the longest available follow-up for patients who have undergone laparoscopic cryoablation for SRMs was published in 2010 by Aron et al. (32). This study reviewed 55 patients with biopsy proven RCC with a median follow-up of 93 months and found a 5-year disease-free survival of 81%, cancer-specific survival of 92%, and overall survival of 84%.

Outcomes after Radiofrequency Ablation

Oncologic outcomes after RFA are similar to cryoablation. A meta-analysis published in 2012 by El Dib et al. (29) demonstrated a pooled proportional oncologic efficacy of 89% with cryoablation (457 cases) and 90% with RFA (426 cases). Levinson and colleagues (33) included 18 patients with biopsy proven RCC with a mean follow-up of 57.4 months. They found a recurrence-free survival of 90.3% and a cancer-specific and metastatic-free survival of 100%. McDougal et al. (34) reported a 91% recurrence-free survival in a series of 16 patients with pathologic confirmed RCC with 4 years follow-up. Metastatic and disease-specific survival were also 100% in this series. In a study from our institution, Tracy et al. (35) reviewed 243 renal tumors that were treated via percutaneous ablation with a mean follow-up of 27 months. Among the 179 masses that were biopsy proven RCC, 5-year recurrence-free survival was 90%, metastatic-free survival was 95%, and disease-specific survival was 99%. Another more recent study from our institution reported specifically on 77 patients who underwent laparoscopic RFA for management of 111 renal masses with a median follow-up of 59 months. Among the patients who had biopsy proven RCC, 5-year recurrence-free survival was 92% with 5-year metastatic-free survival being 100% (11).

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CHAPTER 10 LAPAROSCOPIC AND ROBOTICALLY ASSISTED PYELOPLASTY IN ADULTS

J. STUART WOLF JR.

Pyeloplasty is a first-line option for the management of ureteropelvic junction (UPJ) obstruction. The reconstructive techniques have evolved over the years, and most recently, the laparoscopic approach (with or without robotic assistance) has been introduced. In properly selected cases and with requisite expertise, laparoscopic pyeloplasty provide the same technical success as open surgical laparotomy and is associated with a shorter and less intense convalescence. The technique is well-established and reproducible, although there are situations that might prompt consideration of the open surgical approach such as extensive tissue deficit in the setting of prior surgery. Laparoscopic suturing is the most technically demanding portion of the procedure, such that manual suturing devices or robotic assistance can facilitate the procedure. This chapter summarizes the pre-, intra-, and postoperative considerations for laparoscopic pyeloplasty.

DIAGNOSIS

UPJ obstruction can present symptomatically, or it can be detected incidentally. Flank pain is the most common presenting symptom. Infection, urolithiasis, and/or impaired renal function can result as well. The radiographic finding of unilateral hydronephrosis and a normal ureter (on computerized tomography, magnetic resonance imaging, or ultrasonography) together with ipsilateral flank pain (classically episodic and related to fluid or alcohol intake) is sufficient to make the diagnosis. When the diagnosis is uncertain or if surgery is considered, however, further information such as estimation of differential renal function and quantification of outflow obstruction might be desirable and can be obtained with nuclear medicine renal scintigraphy. At the time of pyeloplasty, or in some cases as a separate procedure, retrograde ureteropyelography is recommended to confirm the diagnosis and determine the UPJ anatomy.

INDICATIONS AND CONTRAINDICATIONS

Indications for pyeloplasty include symptomatic UPJ obstruction or UPJ obstruction resulting in pyelonephritis, urolithiasis, and/or impaired renal function. Repair of asymptomatic UPJ obstruction that has not led to these sequelae can be offered, with the intention of preventing future problems. There are no absolute contraindications to the laparoscopic approach to pyeloplasty except the usual surgical contraindications (untreated coagulopathy, active infections, etc.). Significant prior infections, intrarenal pelvis, or prior pyeloplasty will make the laparoscopic approach more challenging, but with experience, these cases can be managed laparoscopically. The combination of any of these with extensive tissue deficit, however, should prompt consideration of open surgery. In the absence of significant urinary leakage, prior endopyelotomy is not usually problematic.

ALTERNATIVE THERAPIES

The most common alternative to pyeloplasty is endopyelotomy, which is the endoscopic incision of the obstructed UPJ and intended healing of the ureter over a stent to provide a wider lumen. Following initial enthusiasm, there is now recognition that endopyelotomy for primary UPJ obstruction does not have favorable long-term results (1–6). Its best role may be in the management of pyeloplasty failures (secondary UPJ obstruction). In ill patients, chronic ureteral stenting may be considered as an alternative to definitive surgery.

PREOPERATIVE PREPARATION

Treat bacteriuria prior to surgery. Bowel preparation is not necessary. After the patient has taken nothing by mouth for 6 hours, and after administering intravenous antibiotics effective against skin and genitourinary organisms, place the patient under general anesthesia with oral endotracheal intubation.

INSTRUMENTATION FOR NONROBOTIC LAPAROSCOPY

The following list includes all of the instrumentation needed for all of the surgical steps described. Not all equipment is needed in all cases, and a variety of preferences will alter the list.

- Nondisposable
    - Laparoscope, 30- or 45-degree lens
    - Video instrumentation and light source
    - Surgical instruments
        - Scissors: standard and microscissors (right-angle scissors are helpful but not necessary)
        - Needle holders
        - Graspers: Maryland, bowel, and bipolar
        - Fascial closure device
        - Needle-suture passer
- Disposable
    - Laparoscopic ports, 5- and 12-mm
    - Veress needle or other abdominal access device
    - Insufflation tubing
    - Irrigator-aspirator
    - Dissection device (monopolar or bipolar cautery, ultrasonic, others)
    - Endo Stitch (Covidien, Norwalk, Connecticut)
    - Umbilical tape or vessel loop
    - Sutures
        - 4-0 Polysorb for Endo Stitch
        - 4-0 braided, monofilament, or barbed suture for free-needle suturing
        - Keith needle for retraction
        - Skin closure suture (or wound glue)
    - 10Fr round closed suction drain catheter
    - Internal ureteral stent
    - Urethral catheter

SURGICAL STEPS

Cystoscopy, Retrograde Ureterography, and Ureteral Stent Placement

Confirm ureteral and renal pelvic anatomy with cystoscopy and retrograde ureterography (can be omitted if retrograde ureterography has already been performed) and place a ureteral stent. Some surgeons place the stent in an antegrade fashion laparoscopically. Insert a urethral catheter to drainage.

Position for Laparoscopy

Place the patient in a modified lateral decubitus position, 45 degrees from horizontal, with the ipsilateral side up on a flat table without flexion. Pad all pressure points well. Bring the ipsilateral arm over the chest and fix it in a neutral position.

Laparoscopic Entry and Port Placement

The transperitoneal route is most popular because it provides more room for suturing and better angles for transposition of the UPJ anterior to crossing vessels when felt necessary. Figure 10.1 illustrates typical port placement for a right-sided laparoscopic pyeloplasty. The midline ports are for the laparoscope (middle port) and the surgeon (working through the umbilical port and the most cephalad port). The fourth port is in a lateral position, in line with the umbilicus, for the assistant surgeon. In an obese patient, displace the ports laterally and cephalad. All ports are 5 mm initially, assuming a 5-mm laparoscope is available. The umbilical port is placed directly through the base of the umbilicus. If the Endo Stitch device is used for the repair, then increase the umbilical port from 5 to 12 mm. Obtain access at the lateral port site using your preferred method and place the remaining ports. Consider infiltrating all port sites with 0.5% bupivacaine (7).

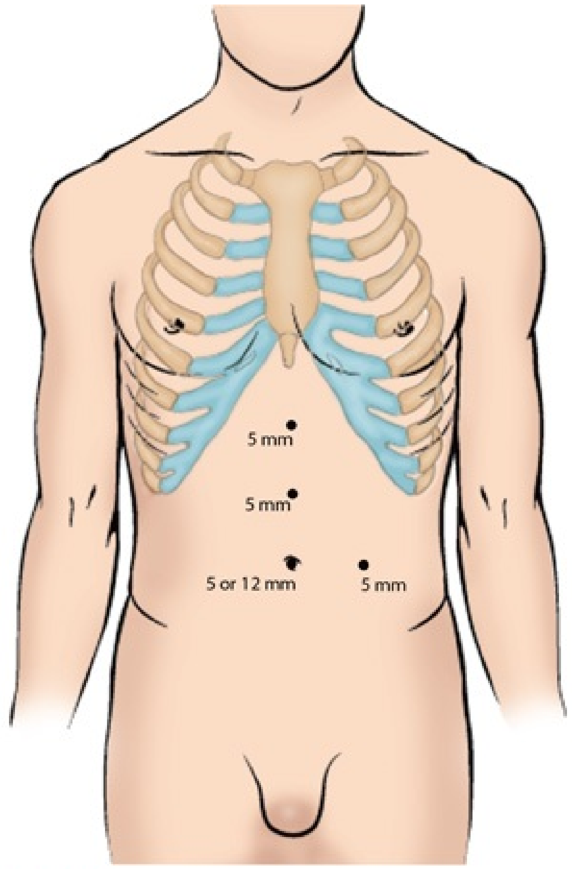

FIGURE 10.1 Port placement for left-sided transperitoneal laparoscopic pyeloplasty.

Exposure of Operative Field

If the UPJ is visible under the colonic mesentery when performing a left-sided pyeloplasty, consider a transmesenteric route, which is more expedient. In most cases, however, reflect the colon and mesentery, staying outside Gerota fascia until reflection is complete. Liver or splenic retraction usually is not needed. Bowel mobilization is complete when the medial aspect of the lower pole of the kidney, up to the renal hilum, can be seen without active retraction of bowel (in obese patients, a bowel retractor may be required). Then, incise Gerota fascia to expose the renal pelvis, UPJ, and proximal ureter.

Dissection of Ureteropelvic Junction

Expose the UPJ either by identifying the renal pelvis and dissecting caudally or by identifying the ureter and proceeding cephalad. Free up the lower aspect of the renal pelvis, UPJ, and proximal ureter from surrounding tissue. The degree of mobilization required depends on the selected repair. Preserve any lower pole crossing vessels. Stabilize the ureter and/or renal pelvis as needed with a vessel loop placed through the abdominal wall with a needle-suture passer or a suture on a Keith needle.

Decide on Type of Repair

Select the type of repair before incising the UPJ. The Anderson-Hynes dismembered pyeloplasty (Fig. 10.2) is the most versatile repair because the obstruction is completely resected and the UPJ transposed in front of any anterior crossing vessels. Although the renal pelvis can be tapered during a nondismembered repair, doing so is more straightforward with dismemberment. If transposition in front of crossing vessels is not required, then a nondismembered repair can be used. The most common nondismembered repairs are the Fengerplasty (using the Heineke-Mikulicz principle, Fig. 10.3) and the Y-V plasty (Fig. 10.4). The latter can be used for long obstructed segments (Fig. 10.5), although it is usually applied for short obstructions. If the obstructed segment is long and the tissue cannot be mobilized enough for an Anderson-Hynes pyeloplasty or a Y-V plasty, then consider a flap pyeloplasty (Fig. 10.6) if there is adequate renal pelvis. This type of repair is more difficult, however, and should be attempted laparoscopically only if there is generous tissue of good quality. In selected cases, ureterolysis and vasculopexy (freeing up the ureter and crossing vessel[s] and relocating the vessel[s] to a new position using sutures placed in the perivascular tissue) can be considered (8–10), but more commonly, this is combined with another type of repair. Finally, when small renal stones are present, they can be removed using the simple technique of laparoscopic pyelolithotomy.

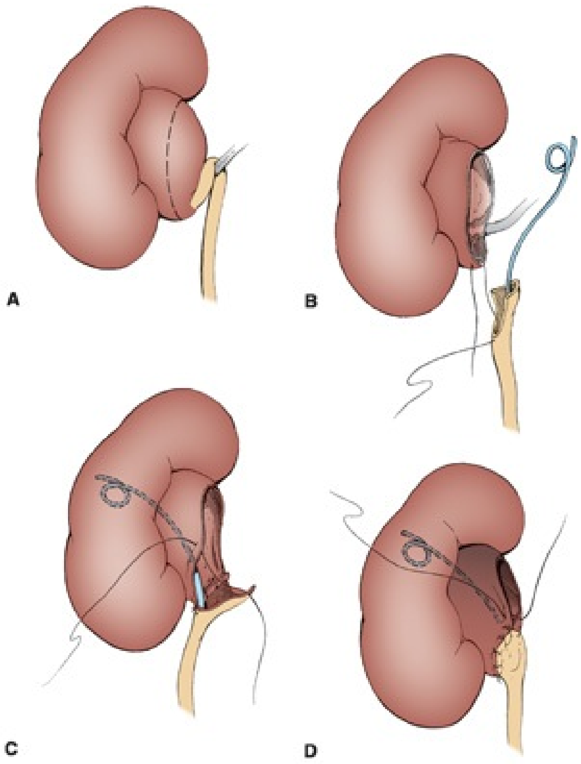

FIGURE 10.2 Anderson-Hynes dismembered pyeloplasty.

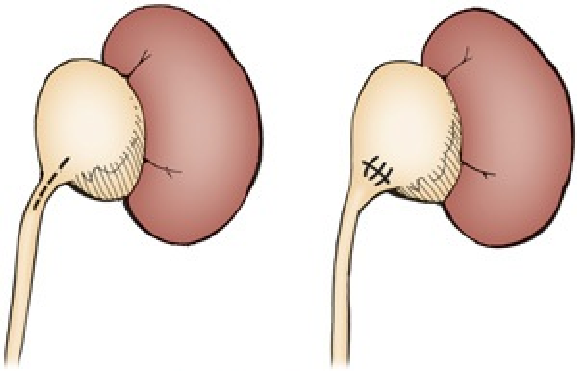

FIGURE 10.3 Fengerplasty.

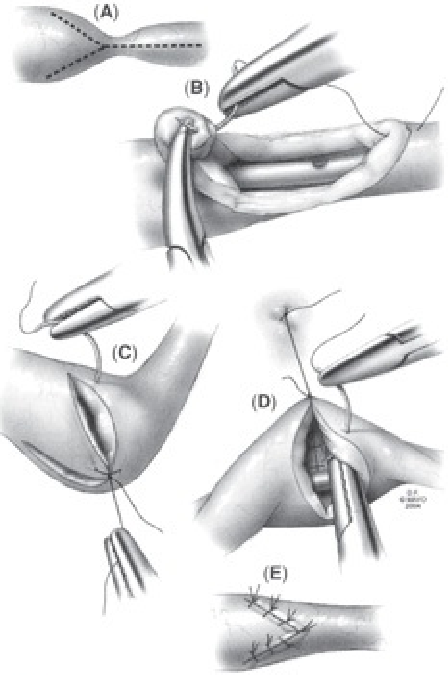

FIGURE 10.4 Y-V plasty. (Reprinted with permission from Taylor & Francis Group, LLC, from Chow GK. Laparoscopic pyeloplasty: technique. In: Gill IS, ed. *Textbook of Laparoscopic Urology*. New York: Informa Healthcare, 2006:295–302.)

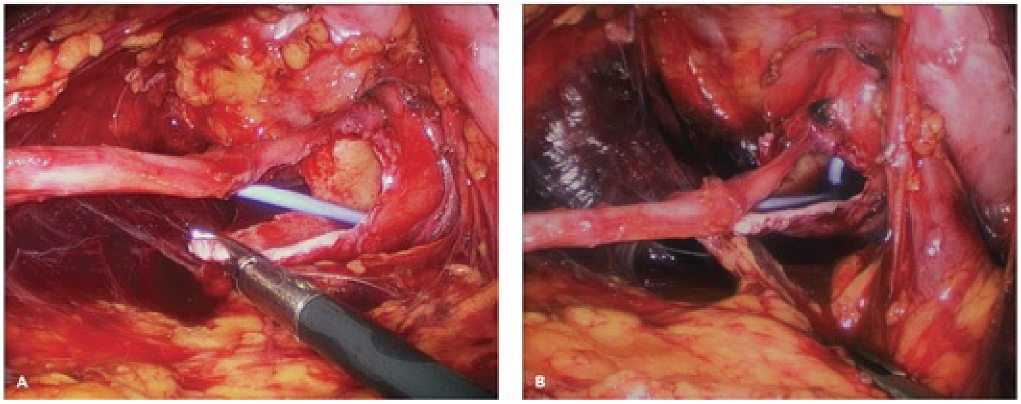

FIGURE 10.5 Intraoperative photograph of Y-V plasty for a long obstruction. **A:** Pelvic flap moved inferiorly toward apex of ureteral incision. **B:** First suture tied down.

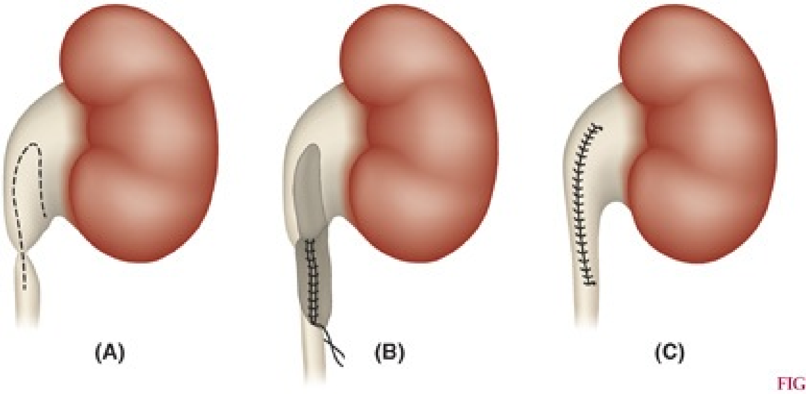

FIGURE 10.6 Flap pyeloplasty.

Anderson-Hynes Dismembered Pyeloplasty

Make the initial incision into the renal pelvis with a scissors placed through the cephalad port. First, create the anterior pyelotomy, cutting from the upper medial aspect of the renal pelvis toward the lateral corner of the UPJ, being aware that the lateral extent of the incision determines the inferior aspect of the renal pelvis for anastomosis, so care must be taken not to carry this incision too close to the kidney. Include the renal pelvic tissue to be discarded (i.e., tapering of the renal pelvis) inferior to this incision, leaving it on the ureter. If the angles allow (or if right-angle scissors are available), then spatulate the proximal ureter on its lateral side after completing the anterior pyelotomy. Stabilization of the ureter (by attachment to the renal pelvis) facilitates this step. If the spatulation cannot be performed now, then do it after completing the dismemberment. Incise the posterior pyelotomy in line with the anterior pyelotomy to completely dismember the UPJ. Leaving the flap of renal pelvic tissue that will eventually be discarded on the ureter for now serves as “handle” for manipulating the ureter. Transpose the renal pelvis and ureter in front of the crossing vessels (when present). Mobilize the proximal ureter and/or renal pelvis as necessary to achieve a tension-free repair.

Options for suturing with non–robotic-assisted laparoscopy include the Endo Stitch and free-needle suturing. If the tissue has adequate thickness and is not friable, and if the ureteral lumen is adequate, then using the Endo Stitch for the Anderson-Hynes pyeloplasty facilitates suturing and knot tying (Fig. 10.7). In all other situations, however, free-needle suturing is recommended because the needle is smaller and can be placed more delicately and at more varied angles. Use a barbed suture to obviate the need to constantly reapply tension.

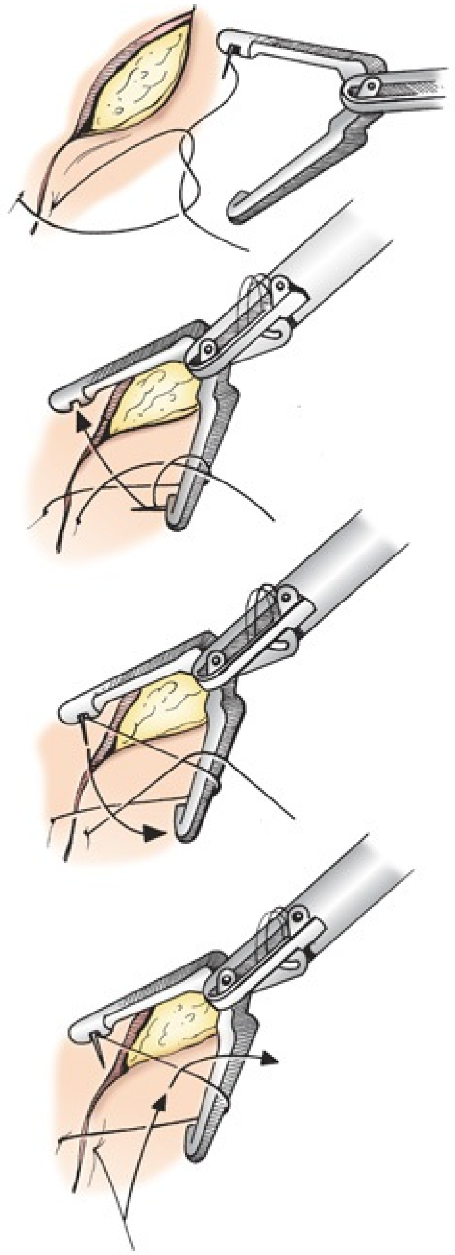

FIGURE 10.7 One of several methods of knot tying with the Endo Stitch device.

Place the first suture of the Anderson-Hynes pyeloplasty outside-in at the inferior apex of the renal pelvis and then inside-out at the inferior apex of the ureteral spatulation. For the first knot, which sets up the remaining repair, a simple knot will suffice if there is no tension but using a surgeon’s knot or a slip knot will ensure good tissue coaptation. Throw this first knot with the suture anterior to the renal pelvis. Because it is easier to close the posterior aspect of the anastomosis first, transfer the needle lateral to the ureter to move it posteriorly. Run the suture to complete the posterior anastomosis of the spatulated ureter to the renal pelvis. Make the bites close together to create a watertight closure. Excise the portion of the flap of pelvic tissue to be discarded, tapering it to match the angle of the anterior closure. With a new suture, complete the anterior anastomosis of the spatulated ureter to the renal pelvis in a running fashion, starting from the caudad aspect, and then continue cephalad to eventually suture renal pelvis to renal pelvis. If a large amount of renal pelvic tissue has been excised, then a third suture might be needed to complete the pyelotomy closure. When the repair is complete, the renal pelvis is tapered and the funnel-shaped UPJ is dependent.

Y-V Plasty

Use a microscissors, if available, to make the fine incisions for Y-V plasty. For the typical short obstruction, initially incise at the anterior aspect of the UPJ at the site of obstruction. Create the lateral arm of the "Y," starting at the initial incision and angling cephalad and toward the kidney. Then, incise the medial arm of the "Y" at about a 60-degree angle. The arms should be of about equal length, and for a short obstruction only need to be a centimeter or so long. Create the caudal stem of the "Y" inferiorly along the anterior aspect of ureter until healthy ureter is reached. Place the initial suture between the apex of the ureteral incision and the tip of the renal pelvic flap. Free-needle suturing is optimal for Y-V plasty. Advance the pelvic flap into the ureteral incision with the first knot and then the approximate appearance of the repair can be appreciated. Place additional interrupted sutures to close the lateral and medial aspects of the repair.

Laparoscopic Pyelolithotomy

If renal stones are present, then insert a flexible cystoscope through a laparoscopic port and through the pyelotomy (before anastomosis) into the renal pelvis. Irrigate through the cystoscope with normal saline. Engage stones with a nitinol tipless basket and remove the cystoscope and stone together out the laparoscopic port.

Drain Placement and Exit

Reduce the pneumoperitoneum pressure to 5 mm Hg and assess for bleeding. Close the fascia of any 12-mm port sites. Place a 10Fr round closed suction drain at the umbilical site, which hides the more prominent scar that occurs when the skin is not closed at the drain site (a 10Fr round drain can fit through the fascia even if the fascia of a 12-mm site has been closed). Desufflate and then close the skin with sutures or wounds glue.

SURGICAL ALTERNATIVES

Laparoendoscopic Single-Site Surgery, Natural Orifice Transluminal Endoscopic Surgery, and Mini-Laparoscopy

Surgical modifications have been made in attempts to improve the cosmesis of laparoscopic pyeloplasty, especially given that the procedure is often performed in young healthy patients for whom this is an important consideration. Options include laparoendoscopic single-site surgery (11), natural orifice transluminal endoscopic surgery (NOTES), and mini-laparoscopy (12). The experience with all of these techniques is limited (in fact, pure NOTES pyeloplasty has been reported only in the experimental setting as of the time of this writing), but further advances might bring them more into the mainstream.

Robotic-Assisted Laparoscopy

The robotic-assisted approach to laparoscopic pyeloplasty has achieved great popularity in recent years, owing to both proliferation of robotic systems used for other (more common) procedures and the aforementioned difficulty with standard laparoscopic suturing. The da Vinci robotic surgical system (Intuitive Surgical, Sunnyvale, California) provides magnification, three-dimensional stereoscopic vision, motion scaling, and tremor filtering to assist suturing. Patient positioning is as described previously. Ports include a 12-mm port for the camera, a 5-mm port for the assistant (to insert suture, provide irrigation and aspiration, etc.), and two or three 5- or 8-mm robotic ports (the third robotic arm, if available, is primarily used for retraction, but not all surgeons use the third arm for this procedure). One configuration for port placement is illustrated in Figure 10.8. Mobilization of the colon and exposure of the UPJ are performed using standard laparoscopic instrumentation as described previously. Robotic assistance can be used for the entire procedure, or only for the suturing +/− the UPJ dissection portions of the procedure. A common robot docking position is from the patient's back at a 45-degree angle from the ipsilateral shoulder toward the umbilicus such that the robotic arms reach across the patient's abdomen and angle back toward the ipsilateral upper quadrant. The 30-degree down-angled da Vinci laparoscope is used. The procedure is then performed as described earlier. Surgeons should be familiar with the standard laparoscopic approach so that the procedure can be completed in the (unlikely) event of robotic malfunction.

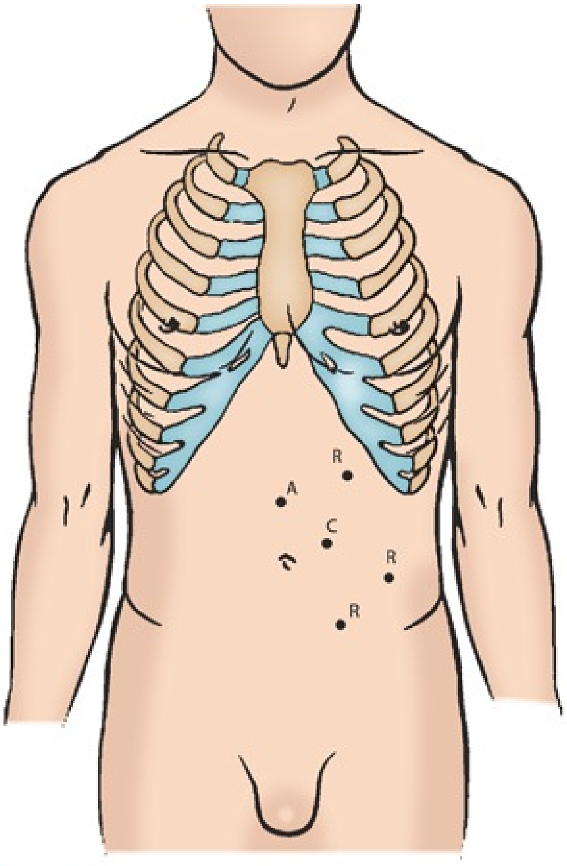

FIGURE 10.8 Port placement for left-sided transperitoneal robotic-assisted laparoscopic pyeloplasty. *A*, 5-mm port for assistant; *C*, 12-mm port for videolaparoscope; *R*, 5- or 8-mm robotic ports (the most inferior robotic port is optional, for robots with a third arm).

POSTOPERATIVE CARE

Advance the patient's diet as tolerated. Use parenteral ketorolac and narcotics as needed for pain control, transitioning from parenteral to oral medications as tolerated. Maintain the urethral catheter and drain until the morning of the second postoperative day (or the first postoperative day if the patient is doing well and might be ready for discharge that day). First remove the urethral catheter and then remove the suction drain and discharge the patient a few hours later after the patient has voided and if the drain output remains low. If there is concern about urine leak, measure creatinine level of the drain fluid and do not remove the drain if the level is elevated.

INTRAOPERATIVE COMPLICATIONS

Aside from general concerns during laparoscopic abdominal surgery, pay specific attention to potential complications regarding the upper tract collecting system and renal vasculature. Approach hemostasis of the incised collecting system tissue cautiously, using bipolar or ultrasonic energy to reduce the risk of devascularization. Tolerate minor oozing. Similarly, take great care when dissecting any crossing vessels. Finally, carefully plan the incisions into the renal pelvis to set up the repair, especially regarding the initial renal pelvic incision. If the incision is too cephalad, especially at the lateral aspect, then the bottom of the renal pelvis that is to be closed to the ureter is inadequate.

POSTOPERATIVE COMPLICATIONS

If the drain contains urine, reinsert the urethral catheter and send the patient home with the drain in place. Remove the drain when output ceases. A leak for more than a week is rare.

PUBLISHED LITERATURE

A multi-institutional comparison of standard and robotic-assisted laparoscopic pyeloplasty, which included 759 procedures that could be included in the multivariate analysis, confirmed no difference in outcomes between standard and robotic-assisted laparoscopic pyeloplasty, and that only prior endopyelotomy and crossing vessels reduced freedom from secondary procedures following laparoscopic pyeloplasty (13). A similar finding was made in a systematic review and meta-analysis that assessed 9 published series of 196 standard laparoscopic pyeloplasties and 277 robotic-assisted laparoscopic pyeloplasties; the two approaches were similar in terms of perioperative complications, hospital stay, and success rate, but robotic assistance was associated with shorter operative time (14). This latter report also suggested that laparoscopic pyeloplasty (standard or robotic-assisted) had similar complication and success rates to that of open surgical pyeloplasty, whereas providing shorter hospital stay and a trend toward reduced analgesic requirements (14).

SUMMARY

Laparoscopic pyeloplasty is a well-established and reproducible surgical procedure with extensive worldwide experience. Results are generally excellent, although the procedure is more difficult in certain situations. The most technically challenging aspect is laparoscopic suturing, which can be performed with free-needle suturing (the most demanding technique), using handheld suture assistance devices such as the Endo Stitch device (which is not optimal for all repairs) or with robotic assistance. Laparoscopic pyeloplasty is a first-line option for the management of UPJ obstruction.

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CHAPTER 11 LAPAROSCOPIC ADRENALECTOMY

ARVIN K. GEORGE AND LOUIS R. KAVOUSSI

Since Gagner et al. (1) first described laparoscopic adrenalectomy in 1992, this approach has become the preferred technique in the surgical management of most adrenal lesions. Laparoscopic adrenalectomy demonstrates the classical benefits of minimally invasive surgery, with multiple studies supporting reduction in postoperative pain, analgesia requirements, and postoperative morbidity with equivalent functional outcome when compared with traditional open surgery. Advances in minimally invasive surgical techniques have generated the development of multiple approaches to adrenalectomy, including transperitoneal, retroperitoneal, transthoracic/transdiaphragmatic, and most recently robot-assisted surgery. The benign nature of the majority of adrenal disease, combined with the deep retroperitoneal location of the adrenal gland, has lent itself ideally to a minimally invasive approach.

INDICATIONS

Laparoscopic adrenalectomy is a definitive surgical treatment modality for the broad spectrum of adrenal disease. It has been proven safe and effective in the management of benign functioning and nonfunctioning adrenal conditions as well as the majority of malignant neoplasms (Table 11.1). As surgeon experience has increased, the contraindications to the laparoscopic approach have decreased. In the hands of a proficient and practiced surgeon, contraindications have become relative, and the advantages of minimally invasive techniques have afforded urologists the opportunity of a more aggressive approach in treatment (Table 11.2).

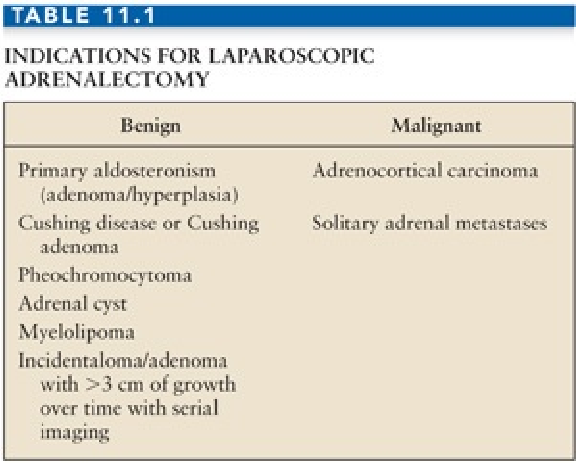

TABLE 11.1

INDICATIONS FOR LAPAROSCOPIC ADRENALECTOMY

Benign	Malignant
Primary aldosteronism (adenoma/hyperplasia)	Adrenocortical carcinoma
Cushing disease or Cushing adenoma	Solitary adrenal metastases
Pheochromocytoma	
Adrenal cyst	
Myelolipoma	
Incidentaloma/adenoma with >3 cm of growth over time with serial imaging	

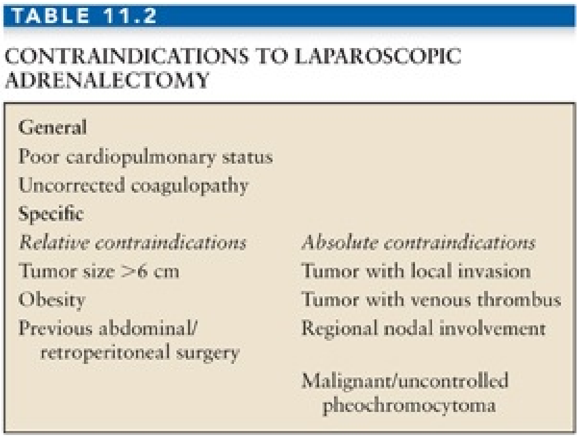

TABLE 11.2

CONTRAINDICATIONS TO LAPAROSCOPIC ADRENALECTOMY

General	
Poor cardiopulmonary status	
Uncorrected coagulopathy	
Specific	
Relative contraindications	*Absolute contraindications*
Tumor size >6 cm	Tumor with local invasion
Obesity	Tumor with venous thrombus
Previous abdominal/ retroperitoneal surgery	Regional nodal involvement
	Malignant/uncontrolled pheochromocytoma

DIAGNOSIS

Evaluation generally begins with serum and urine chemistry to distinguish between functioning and nonfunctioning tumors. More specific investigations, combined with the clinical presentation, assist in isolation of a specific pathology when present (Table 11.3). Imaging with computerized tomography (CT) or magnetic resonance imaging (MRI) is an integral step in preoperative assessment, as it provides detailed characterization of adrenal lesions. The presence of significant retroperitoneal and periadrenal fat allows for ready identification of the gland. CT may help delineate malignant versus benign lesions based on their attenuation characteristics, with accuracy approaching 90% in suspected adrenal disease. CT with assessment of washout is the most useful study in categorizing adrenal incidentalomas with a sensitivity and specificity of 98% and 92%, respectively (2). Attenuation of <10 Hounsfield units on noncontrast imaging is sufficient to identify lipid-rich adenomas <4 cm. Contrast-enhanced imaging at 1 and 15 minutes allows for calculation of absolute percentage washout (APW) and relative percentage washout (RPW) to help characterize lipid-poor adenomas. An APW of >60% and RPW of >40% is typical of benign adenomas (3). Chemical shift MRI with axial in- and out-of-phase images can also be used to differentiate incidental adrenal lesions. MRI has a reported sensitivity and specificity of 89% and 99%, respectively, with adenomas exhibiting a lipid-rich composition in distinction to the lipid-depleted nature of nonadenomatous lesions. Intraoperative ultrasound can elicit detailed information regarding internal acoustic appearance, tumor size, extent of invasion if present, and adjacent anatomy. Its use is a defined element in adrenal-sparing surgery and can assist in cases where it is difficult to distinguish the periadrenal fat from the gland proper. Progress in imaging techniques and their interpretation has increased diagnostic accuracy, and they are an essential adjunct in determining diagnosis, operability, and surgical approach.

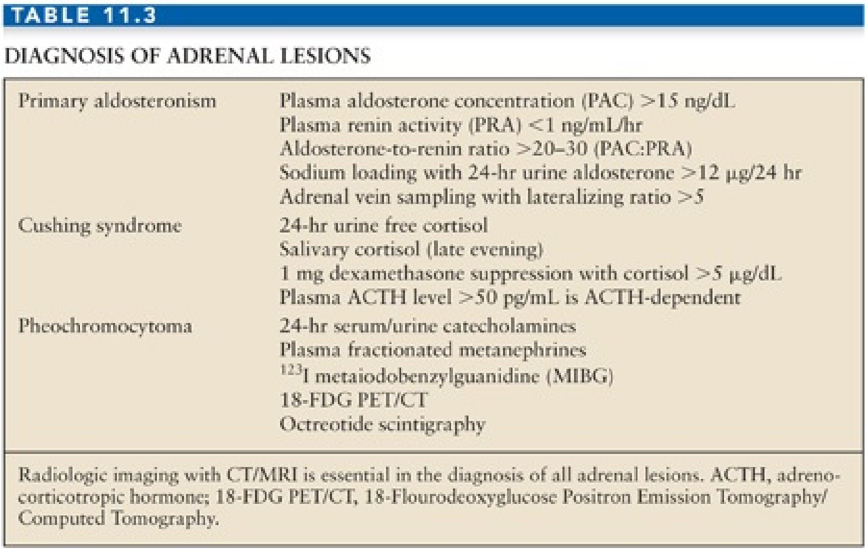

TABLE 11.3

DIAGNOSIS OF ADRENAL LESIONS

Primary aldosteronism	Plasma aldosterone concentration (PAC) >15 ng/dL
	Plasma renin activity (PRA) <1 ng/mL/hr
	Aldosterone-to-renin ratio >20–30 (PAC:PRA)
	Sodium loading with 24-hr urine aldosterone >12 µg/24 hr
	Adrenal vein sampling with lateralizing ratio >5
Cushing syndrome	24-hr urine free cortisol
	Salivary cortisol (late evening)
	1 mg dexamethasone suppression with cortisol >5 µg/dL
	Plasma ACTH level >50 pg/mL is ACTH-dependent
Pheochromocytoma	24-hr serum/urine catecholamines
	Plasma fractionated metanephrines
	^{123}I metaiodobenzylguanidine (MIBG)
	18-FDG PET/CT
	Octreotide scintigraphy

Radiologic imaging with CT/MRI is essential in the diagnosis of all adrenal lesions. ACTH, adrenocorticotropic hormone; 18-FDG PET/CT, 18-Flourodeoxyglucose Positron Emission Tomography/Computed Tomography.

ALTERNATIVE THERAPY

Alternative treatment for adrenal lesions include conventional open surgery via a transabdominal or retroperitoneal approach, radiofrequency ablation (RFA), and cryoablation (4). Ablative therapies are currently reserved for those patients who are not surgical candidates or who refuse surgery.

RFA provokes local ion agitation and heat, inducing coagulative tissue necrosis. In one recent study, Mayo-Smith and Dupuy (5) demonstrated the successful treatment of hormonally active tumors and small (5 cm) solitary adrenal metastases/adrenocortical carcinoma. RFA has also shown promise in the management of adrenal metastases and select patients with functional masses. In a study of 23 ablations, technical success and good local control in 81% of patients with short-term follow-up was reported, but eventual disease progression occurred in 16 of 19 patients treated for metastatic disease (6).

Cryoablation relies on the Joule-Thomson effect, or the change in temperature that accompanies expansion of a gas (argon) with resultant cooling and formation of intracellular ice crystals. Munver et al. (7) described the first case of cryoablation as an adrenal-sparing procedure for hyperaldosteronism, with subsequent reduction in the need of antihypertensives postoperatively. A retrospective series of 12 patients undergoing cryoablation for adrenal metastases demonstrated local control in 92% of patients, although 50% experienced hypertensive crisis highlighting the need for preoperative alpha blockade (8).

RFA and adrenal cryoablation show potential as less invasive surgical alternatives for small lesions and adrenal-sparing procedures in patients who are not ideal surgical candidates. The current experience as described in the literature is limited and further evaluation of such alternative therapies is needed.

SURGICAL TECHNIQUES

The transperitoneal approach is preferred by most surgeons due to the greater working space and familiarity of anatomic landmarks. Retroperitoneoscopic adrenalectomy is generally considered by the more experienced surgeon but may prove useful in patients with significant prior intra-abdominal surgery and/or morbid obesity. Thoracoscopic adrenalectomy was described by Gill et al. (9) for the treatment of select patients with adrenal pathology and significant abdominal and retroperitoneal scarring from previous surgery through access via the virgin thoracic cavity and transdiaphragmatic approach. In an effort to further minimize operative morbidity and improve cosmesis, the introduction of laparoendoscopic single-site (LESS) adrenalectomy has been evaluated. A systematic review of LESS adrenalectomy versus conventional laparoscopic adrenalectomy revealed equivalent complication, conversion, and transfusion rates despite a longer operative time in those undergoing a single-site procedure, likely related to the early experience of this novel technique (10). Additionally, there were comparable cosmetic satisfaction scores, although LESS adrenalectomy demonstrated lower visual analog pain scores. The introduction of robotic technology in the minimally invasive arena has proven to be a successful alternative to other surgeries with specific benefits. Robotic systems aid in eliminating surgeon fatigue, tremor, and provide a three-dimensional visualization of the operative field. However, they represent a more costly option to the healthcare system and require additional training by the surgeon. A prospective trial of laparoscopic versus robot-assisted adrenalectomies failed to show significant benefit in the latter (11). The study demonstrated that robot-assisted adrenalectomy is a feasible alternative to standard laparoscopic surgery with appropriate robotic experience. Ultimately, the choice of surgical technique is dependent on surgeon experience, the patient's past surgical history, and preoperative findings.

Preoperative Considerations

Prior to operative intervention, metabolic abnormalities associated with hormonally active tumors must be addressed to optimize the patient for surgery. A multidisciplinary approach integrating the patient's primary care provider, endocrinologist, and urologist ensures appropriate care in the preoperative setting and maintains follow-up after surgery. Hypertension and hypokalemia seen with aldosteronomas are managed with spironolactone. The patient should be maintained normoglycemic with cortisol-secreting adenomas, and stress-dose steroid administration must occur perioperatively. The preoperative management of pheochromocytomas requires special consideration, as inadequate blockade of circulating catecholamines can trigger hypertensive crises secondary to anesthesia or intraoperative manipulation. Patients should receive 14 days of blockade with phenoxybenzamine hydrochloride titrated to control blood pressure. Additional blockade may be indicated if arrhythmias persist or prior treatment proves insufficient.

A mechanical bowel preparation is optional the night prior to surgery for bowel decompression. Single-dose parenteral antibiotic prophylaxis is given prior to incision. Invasive monitoring via arterial lines and central venous lines is performed as indicated. A urinary Foley catheter allows for bladder decompression and intraoperative urine output assessment. Pneumatic compression stockings are placed on the lower extremities for deep venous thrombosis prophylaxis.

Transperitoneal Laparoscopic Adrenalectomy

The patient is placed in the 45-degree modified flank position and secured with silk tape; all bony pressure points are padded prior to the initial incision. The ipsilateral arm can be folded across the chest or placed in an arm rest (Fig. 11.1).

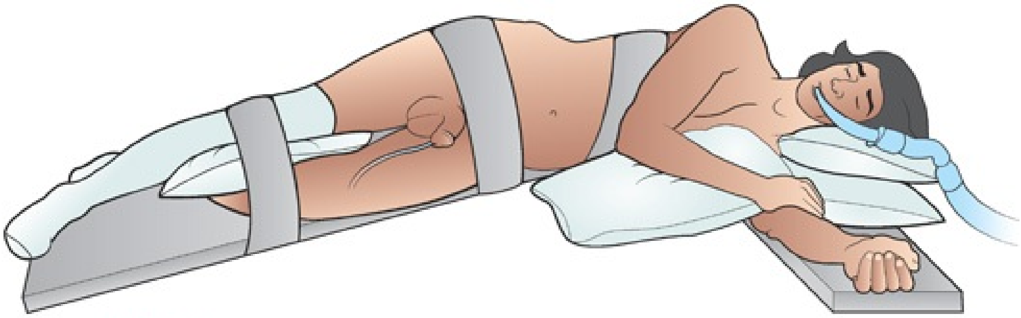

FIGURE 11.1 Laparoscopic transperitoneal adrenalectomy. Patient is positioned in the modified or full flank position for transperitoneal and retroperitoneal approaches, respectively. All bony pressure points are adequately cushioned and the patient is secured in position with silk tape.

Four ports are used for laparoscopic instrumentation. Initial access is obtained at the level of the umbilicus. A Veress needle is inserted and with CO_2 insufflation, intra-abdominal pressure is increased to 20 mm Hg. This is replaced with a 12-mm laparoscopic port into which a 30-degree lens laparoscope is introduced. The remaining trocars are placed under direct vision at the ipsilateral rectus and 4 cm below the costal margin, and midclavicular line and 6 cm below the costal margin, and additional 4 cm below the xiphoid (Fig. 11.2). The camera is placed in the midclavicular line, and the umbilical port site is used for cephalad retraction of the liver or insertion of a paddle retractor for bowel manipulation. Pneumoperitoneum can be subsequently reduced to 15 mm Hg for the remainder of the operation.

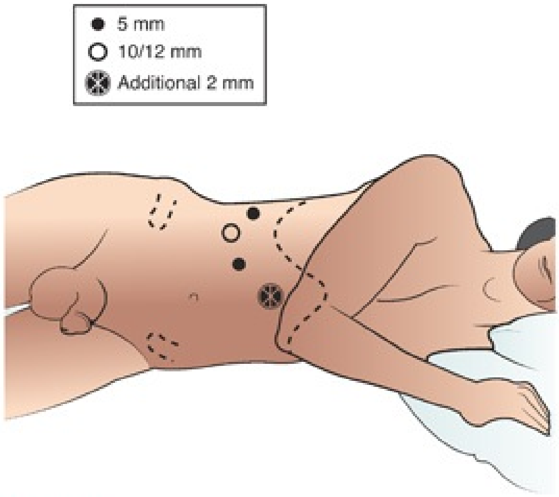

FIGURE 11.2 Laparoscopic transperitoneal adrenalectomy. The primary camera port site is located 6 cm below the costal margin at the midclavicular line. The remaining trocars are placed under direct vision 4 cm below the costal margin in the anterior axillary line and 4 cm below the xiphoid, and additional assistant/retraction port is placed at the umbilicus as illustrated.

Transperitoneal Left Adrenalectomy

Adrenal exposure begins with incising the line of Toldt with endoscopic scissors/electrocautery, which allows for medial mobilization of the splenic flexure and descending colon (Fig. 11.3). The splenocolic and lienorenal ligaments are divided and the spleen is mobilized medially to expose the adrenal in the retroperitoneal space (Fig. 11.4). The fascia of Gerota is opened at the upper pole of the kidney and the periadrenal fat is visualized. Dissection is continued to develop the plane between the tail of the pancreas and the renal hilum. The adrenal vein is identified emptying into the renal vein. The adrenal vein is clipped and divided with a minimum of two clips on the medial aspect (Fig. 11.5). Early ligation prevents systemic insult of catecholamines associated with adrenal manipulation and limits the potential for tumor micrometastases. Superiorly, care is taken to control contributions of the inferior phrenic artery to the adrenal. Larger vessels may be clipped and transected or coagulated with the harmonic scalpel. The adrenal gland is freed from its lateral and inferior attachments with gentle inferior traction on the kidney (Fig. 11.6), at which point renal artery branches to the adrenal can be seen and controlled (Fig. 11.7). The adrenal gland and periadrenal fat are then placed in a laparoscopic retrieval bag and delivered through the largest port site (Fig. 11.8). The surgical field is examined at 5 mm Hg for adequate hemostasis. Finally, the fascial layer of the 12-mm port site is repaired with absorbable suture, and laparoscopic exit is completed in standard fashion.

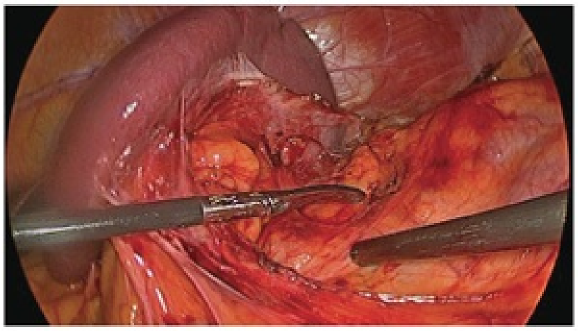

FIGURE 11.3 Transperitoneal left adrenalectomy. Initial exposure begins with incising the white line of Toldt with endoscopic scissors/electrocautery, which allows for gravity-assisted medial mobilization of the splenic flexure and descending colon.

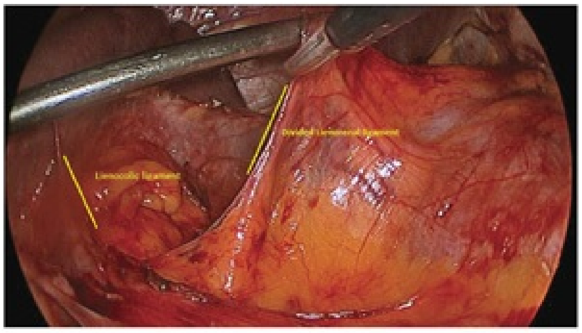

FIGURE 11.4 Transperitoneal left adrenalectomy. The lienocolic and lienorenal ligaments are divided to expose the adrenal in the retroperitoneal space.

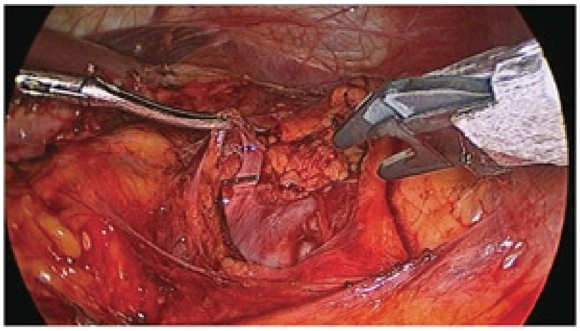

FIGURE 11.5 Transperitoneal left adrenalectomy. The left adrenal vein is ligated with two clips on the side of the renal vein and sharply divided.

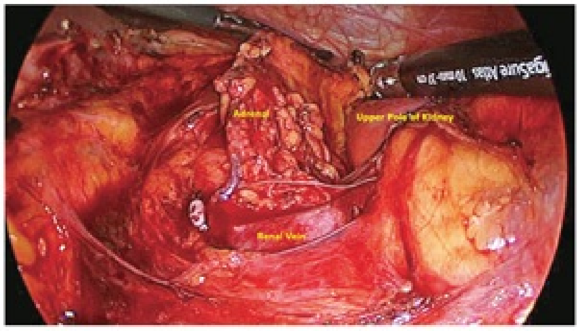

FIGURE 11.6 Transperitoneal left adrenalectomy. The avascular plane between the adrenal and renal upper pole is developed.

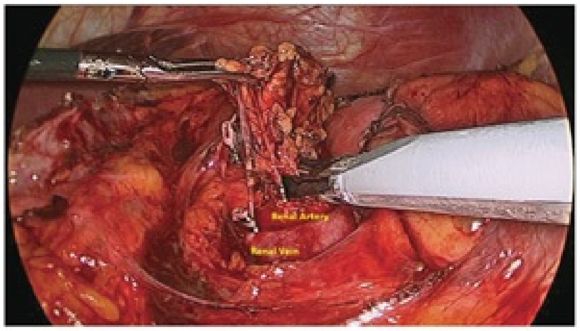

FIGURE 11.7 Transperitoneal left adrenalectomy. Care is taken to control the arterial contributions from the aorta, renal, and inferior phrenic arteries.

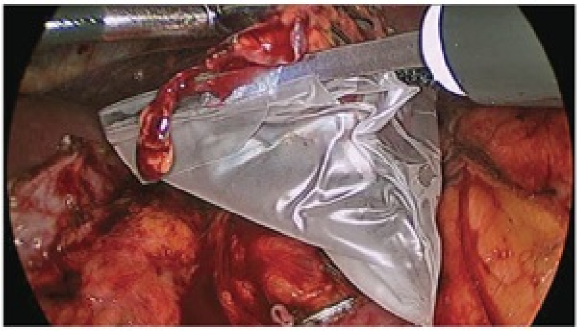

FIGURE 11.8 Transperitoneal left adrenalectomy. The freed specimen is placed in a laparoscopic retrieval bag and removed via the primary port site.

Transperitoneal Right Adrenalectomy

Initial exposure of the adrenal gland begins with cephalad elevation of the liver, which may be completed with a fan retractor or self-retaining locking graspers. The peritoneum is incised at the upper pole of the kidney, close to the liver edge, and the peritoneotomy is extended medially toward the inferior vena cava (Fig. 11.9). In many cases, complete colon mobilization is not necessary, and reflection of the hepatic flexure as needed is sufficient for adequate exposure. At this stage, the adrenal gland should be readily visible and retracted laterally to expose the adrenal vein (Fig. 11.10). It is clipped proximally and distally with two clips on the caval side and divided. Dissection is completed with lateral retraction and elevation of the adrenal to allow mobilization of its superior, medial, and inferior attachments. Careful control of supplying vessels is achieved with hemostatic clips or the harmonic scalpel. The free specimen is then placed in a laparoscopic retrieval bag and delivered through the largest port site. The final steps are completed as described with the left side.

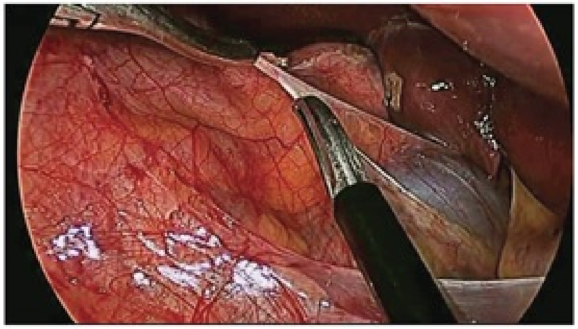

FIGURE 11.9 Transperitoneal right adrenalectomy. The peritoneum at the upper pole of the kidney and overlying the inferior vena cava is incised to expose the retroperitoneum.

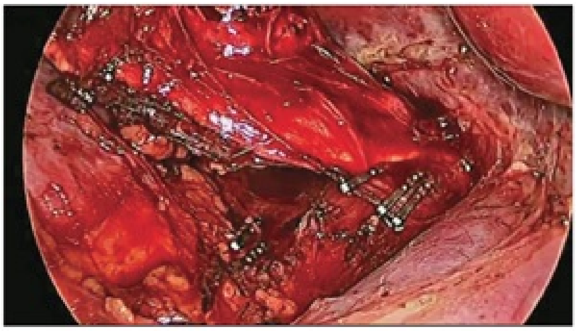

FIGURE 11.10 Transperitoneal right adrenalectomy. After identification of the renal hilum, superior dissection along the inferior vena cava will demonstrate the short, horizontally lying adrenal vein.

Retroperitoneal Laparoscopic Adrenalectomy

The patient is positioned in the lateral decubitus position, stabilized with an inflatable beanbag, and secured and protected as described for the transperitoneal approach. The table is flexed to maximize the operative working space.

A 12-mm transverse skin incision is made at the tip of the 12th rib. The flank muscles are split until the thoracolumbar fascia can be palpated (Fig. 11.11). The fascia is opened and a finger is inserted to allow digital dissection and to develop the retroperitoneal space. A balloon dilator is introduced into the retroperitoneum and inflated to 800 mL. The dilator may then be repositioned more cephalad and reinflated to enable access/vision between the posterior adrenal outside the fascia of Gerota and the diaphragm (Fig. 11.12). The dilator is replaced with a balloon-tipped trocar and sealed against the abdominal wall, and CO_2 pneumoretroperitoneum is created to 15 mm Hg. Under direct laparoscopic visualization with a 30-degree lens laparoscope, an additional port is placed above the iliac crest in the midaxillary line. The final port is placed at the inferior border of the 12th rib where it meets the paraspinal musculature. The anatomic landmarks are identified to ensure localization of the adrenal before mobilization is begun. These include the psoas muscle posteriorly, the fascia of Gerota anteriorly, and the diaphragm superiorly (Fig. 11.13). On the left side, the pancreas lies medially, whereas on the right, it is the liver. Pneumoretroperitoneum is subsequently maintained at 12 mm Hg for the remainder of the operation.

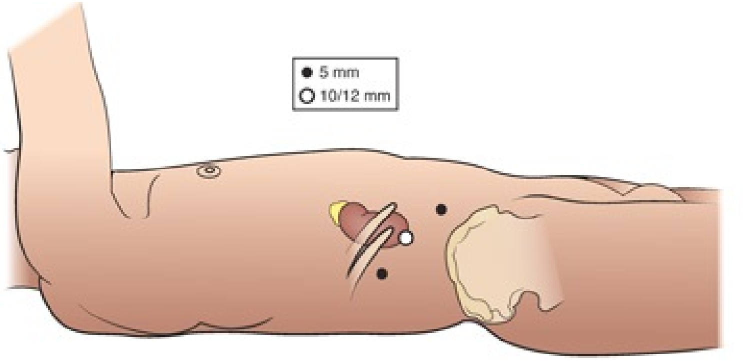

FIGURE 11.11 Laparoscopic retroperitoneal adrenalectomy. Primary port placement is at the tip of the 12th rib. Additional ports are placed under direct laparoscopic vision in the midaxillary line above the iliac crest and the inferior border of the 12th rib, where it meets the paraspinal musculature.

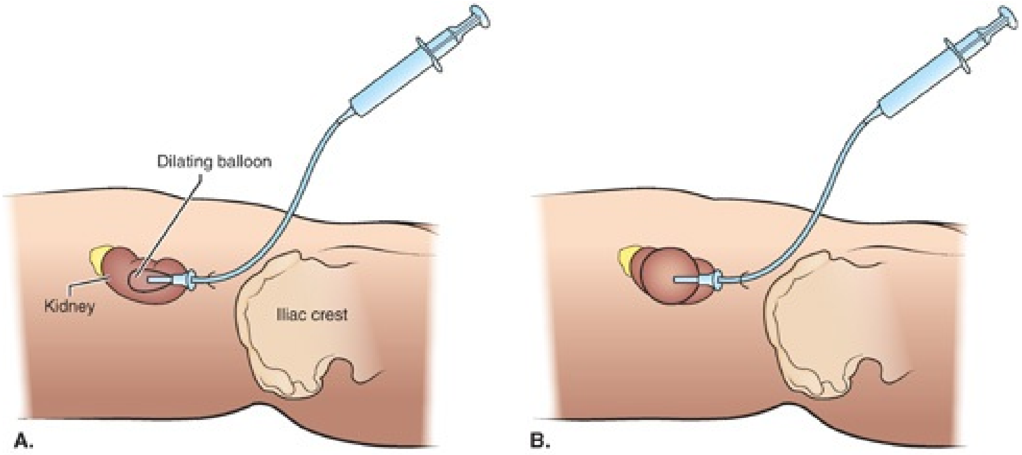

FIGURE 11.12 Laparoscopic retroperitoneal adrenalectomy. **A:** A balloon dilator is inserted into the retroperitoneum and (**B**) inflated to 800 mL. It may be repositioned superiorly and reinflated to maximize exposure and working space before creation of CO_2 pneumoretroperitoneum.

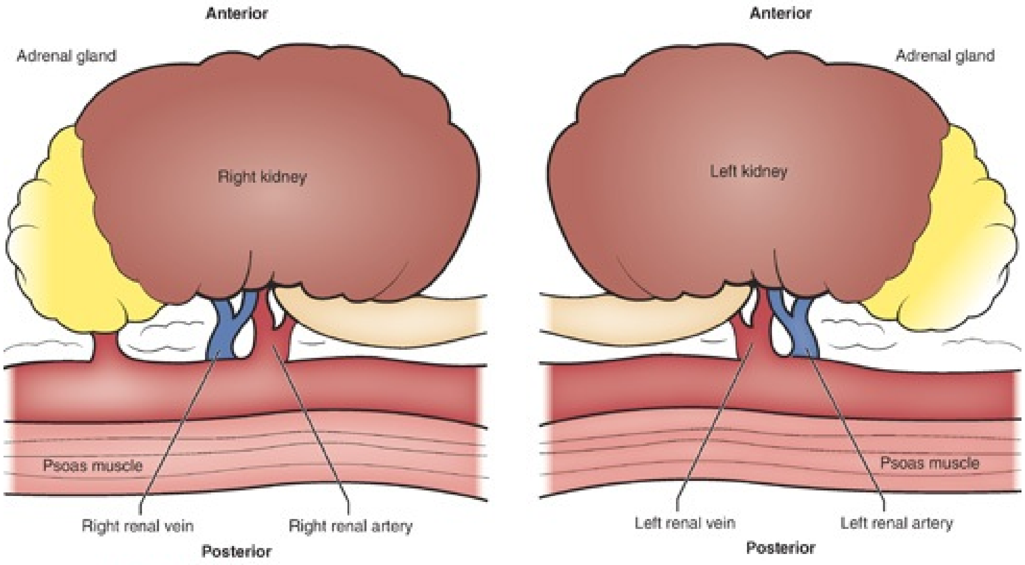

FIGURE 11.13 Laparoscopic retroperitoneal adrenalectomy. Prior to incision of the fascia of Gerota, identification of the anatomic landmarks confirms adequate localization and access to the adrenal. On the right, the liver lies medially, whereas on the left, it is the tail of the pancreas.

Retroperitoneoscopic Left Adrenalectomy

An initial 1.5-cm incision is made transversely along the fascia of Gerota toward the renal upper pole with hook cautery. The perirenal fat is cleaned from the adjacent structures. The plane between the upper pole and adrenal gland is identified and developed with superior retraction of the adrenal and inferior retraction of the kidney. Dissection is continued medially toward the renal hilum, and exposure of the left renal vein facilitates isolation of the adrenal vein arising from the inferomedial border of the gland. The adrenal vein is clip-ligated with two clips on the side of the renal vein and divided. The adrenal is dissected free from the psoas posteriorly and the diaphragm superiorly with ligation of adrenal branches of the inferior phrenic vessels, which may obscure the operative field if not controlled appropriately. Aortic branches arising medially are controlled in a similar fashion with the harmonic scalpel or hemostatic clips. The anterior surface of the adrenal is mobilized from the overlying peritoneum, and the free specimen can then be placed in a laparoscopic retrieval bag for removal via the primary port site.

Retroperitoneoscopic Right Adrenalectomy

Initial access in retroperitoneal right adrenalectomy is similar to the left side. After incision of the fascia of Gerota and clearance of perirenal fat, the vena cava is readily visualized. Dissection is continued superiorly along the cava until the adrenal vein is encountered. The adrenal vein draining from the posteromedial portion of the gland is shorter and more horizontal than its left-sided counterpart and consequently should be approached with caution to avoid tearing. The vein is ligated and divided as previously described. The adrenal is then freed from its remaining attachments with meticulous control of multiple supplying vessels from the aorta, renal hilum, and inferior phrenic artery. Adrenalectomy is then completed as described on the left side.

Robotic Adrenalectomy

The patient is positioned in the lateral decubitus position, stabilized with an inflatable beanbag, and secured and protected as described for the transperitoneal approach. The table is flexed to maximize the operative working space. Four or five ports may be used for robotic instrumentation. Initial access is obtained as described previously. For left robotic adrenalectomy, the initial port placement is a 12-mm camera port placed in the midclavicular line midway between the xiphoid and umbilicus. Two robotic 8-mm trocars are placed; midway between the anterior superior iliac spine and costal margin in the anterior axillary line, and three fingerbreadths below the camera port in the midclavicular line. An assistant port (5 to 12 mm) is placed at the level of the umbilicus. On the right side, an additional 5-mm assistant or robotic port can be placed below the xiphoid for liver retraction completing a quincunx or dice configuration (Fig. 11.14). The robot is docked from the head of the bed, posterior to the patient and at angle to allow for optimal working space and retroperitoneal access. The remainder of the procedure is as outlined for the transperitoneal laparoscopic approach.

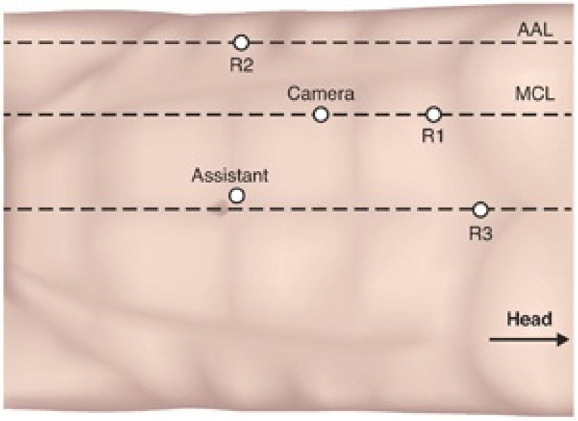

FIGURE 11.14 Robotic right adrenalectomy. Five-port configuration consists of a 12-mm camera port placed in the midclavicular line (*MCL*) midway between the xiphoid and umbilicus. Two robotic 8-mm trocars placed midway between the anterior superior iliac spine and costal margin (*R2*) in the anterior axillary line (*AAL*), and three fingerbreadths below the camera port in the midclavicular line (*R1*). An assistant port (*5* to 12 mm) is placed at the level of the umbilicus. On the right side, an additional *5* mm assistant or robotic port can be placed below the xiphoid for liver retraction (*R3*).

OUTCOMES

Numerous studies have illustrated the safety and efficacy of endoscopic adrenal surgery. Laparoscopic surgery has produced excellent outcomes in hormonally active lesions. Adrenalectomy for aldosteronomas effectively reduces blood pressure in the majority of patients, with long-term cure in 33% to 60% of patients. Patients with subclinical Cushing syndrome showed improvement in glucose control, blood pressure, and obesity following laparoscopic adrenalectomy. Initial concerns regarding laparoscopic treatment of pheochromocytoma and complications which have potential to increase catecholamine release including pneumoperitoneum have been dismissed; one study even described a reduction in intraoperative hypertensive events (35% versus 63%) (12). Controversy also exists regarding the laparoscopic treatment of primary adrenal malignancy. The increased incidence of malignant tumors >6 cm requires careful consideration in surgical approach. Small organ-confined lesions (<6 cm in size) are amenable to laparoscopic excision, but recent series have described conflicting results regarding oncologic efficacy. Miller et al. (13) reported a 30% positive margin rate versus 16% in laparoscopic versus open adrenalectomy groups and a shorter time to recurrence for both stages II and III in the minimally invasive cohort. In contrast, a multi-institutional Italian study revealed no significant differences in local recurrence, time to recurrence, 5-year disease-free survival, or overall survival in a matched cohort of patients controlling for age, sex, lesion size, and stage (14). The current role of laparoscopic adrenalectomy must be tailored to each individual patient without compromising patient safety and ensuring optimal surgical technique with minimal complications (15).

There are several clinical benefits of performing laparoscopic versus open adrenalectomy. Assalia and Gagner (16) demonstrated reduced blood loss (154 versus 309 mL), complication rate (10.9% versus 35.8%), and hospital stay (2.9 versus 7.2 days) when comparing laparoscopic and open surgeries. Additionally, this study demonstrated that laparoscopic surgery utilized less analgesia and had improved cosmesis. These key characteristics translate into increased patient satisfaction as compared to open surgery. Operative times for laparoscopic adrenalectomy are generally longer; this is largely dependent on surgeon experience and has been shown to equilibrate with increased number of cases completed (17). The transperitoneal approach is more often employed by urologists due to familiarity with laparoscopic technique and anatomic landmarks. A prospective randomized study by Rubinstein et al. (18) showed no significant disparity in perioperative morbidity or operative time, emphasizing that the choice of laparoscopic approach lies primarily with the surgeon’s comfort with the procedure coupled with the clinical characteristics of the individual case.

Growing popularity with robotic surgery, mainly through experience with radical prostatectomy, has resulted in feasibility studies of robotic adrenal surgery, and now, comprehensive, robust data sets have become available. A meta-analysis of robotic versus conventional laparoscopic adrenalectomy did not display significant differences in operative time, conversion rate, or postoperative complications (19). Robotic surgery was shown to have a shorter length of hospital stay and lesser estimated blood loss, although patients in the conventional laparoscopy cohort did have a higher body mass index, representing an expected degree of selection bias associated with the early experience of robotic surgery.

Complications

The largest meta-analysis of complications in laparoscopic and open adrenalectomy, by Brunt (20), reported overall complication rates of 10.9% and 25.2%, respectively. Bleeding was the most common complication associated with laparoscopic surgery. Organ injury, including splenic injury requiring splenectomy and pancreatic, diaphragmatic, and large bowel injury, was also decreased. The greatest reduction in morbidity was seen in the incidence of wound (0.6% versus 3.1%), pulmonary, and infectious complications. Thromboembolic phenomena were predominant in obese patients and those with prolonged operative times. The mean conversion rate to open surgery was 3.6%; conversion was most often secondary to intraoperative bleeding, although large tumor size, adhesions, and malignancy with local invasion were also commonly cited reasons. The mean combined mortality rate for laparoscopic adrenalectomy in an analysis of 2,550 cases was 0.2%, and although slightly less than open surgery, the difference has not proven significant. An analysis of National Surgical Quality Improvement Program data for Clavien grades 4 and 5 complications demonstrated an incidence of 7.6% in open surgery and 1.8% for laparoscopic adrenalectomy ($P < .001$); the difference persisted on multivariate analysis when controlling for American Society of Anesthesiologists (ASA) class, wound classification, preoperative functional status, preoperative albumin, and tumor type (OR 3.3) (21). Patients undergoing adrenalectomy for hormonally active tumors must be followed carefully postoperatively because contralateral adrenal suppression can result in metabolic derangements requiring replacement of electrolytes, mineralocorticoids, or glucocorticoids.

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CHAPTER 12 RENAL TRAUMA

JILL C. BUCKLEY AND JACK W. MCANINCH

Renal injuries are relatively uncommon, comprising approximately 2% to 3% of all traumatic injuries (1). The vast majority of renal injuries occur as a result of blunt trauma, are grades I to III, and can be managed nonoperatively (1,2). Penetrating renal trauma usually occurs in conjunction with other intra-abdominal injuries where laparotomy may be required. A grade V renal injury can be life-threatening and may require immediate operative exploration for severe hemorrhage and hemodynamic instability, often resulting in a nephrectomy. The renal injury staging classification was developed by the American Association for the Surgery of Trauma (AAST) to reflect the severity of a renal injury and clinical salvage rates of the injured renal unit. The increasing grade of injury reflects a progressive loss of renal unit with a 100% salvage of grades I and II injuries and only a 4.3% renal salvage rate of grade V injuries (3,4). Grade IV renal injuries represent the most controversial management issue in renal trauma care. Many blunt and penetrating grade IV renal injuries can be successfully managed nonoperatively if the patient has been appropriated staged with computerized tomography (CT) and can be closely monitored in a step down or intensive care unit (ICU) (5,6). If radiographic renal staging is not available or the patient requires immediate abdominal laparotomy for an associated nonurologic injury, renal exploration may be indicated after obtaining an intraoperative single-shot intravenous pyelogram (IVP) to confirm the presence of a contralateral renal unit. In hemodynamically stable patients, renal reconstruction at the time of laparotomy provides excellent functional results in the majority of cases (7). The goal of all renal trauma care is preservation of enough functioning nephron mass to avoid end-stage renal failure if the contralateral renal until was lost or absent. Nephrectomy is reserved for a life-threatening injury where damage control is necessary.

DIAGNOSIS

As with all trauma situations, the patient should undergo an acute assessment and resuscitation as defined by the AAST. The hemodynamic stability of the patient will determine if an immediate operative exploration is required versus radiographic CT staging. The type of trauma (blunt versus penetrating), mechanism of injury (e.g., deceleration injury), physical examination (presence of a rib fracture or spinous process fracture, abdominal or flank tenderness, flank ecchymosis, etc.), associated nonurologic injuries, hemodynamics, and degree of hematuria are important to obtain in the initial assessment. If gross hematuria is not present and the patient is hypotensive, a urine dipstick analysis or formal urine analysis should be performed to detect microscopic hematuria. The degree of hematuria does not correlate with the degree of renal injury but is useful in guiding the initial emergency department assessment.

IMAGING

All penetrating trauma should undergo CT radiographic imaging. Any patient sustaining a blunt trauma injury with a positive physical examination, a deceleration injury, gross hematuria, microscopic hematuria in the setting of hypotension (systolic blood pressure <90 mm Hg in the field or in the emergency department), or serial decreasing hematocrits should undergo radiographic CT imaging to stage the renal injury (1,8). Triple-phase CT radiographic imaging allows detailed staging of the renal injury by evaluating the renal hilum, parenchyma, collecting system, and surrounding tissue as well as detecting other intra-abdominal injuries. It is important to obtain delayed images to document that the collecting system is intact, with contrast passing down into the distal ureter without extravasation (9).

In pediatric trauma patients, special attention should be given to the degree of microscopic hematuria present, as this alone may warrant CT radiographic imaging. Children are often able to maintain their hemodynamics despite underlying hypovolemia; thus, blood pressure readings can be falsely reassuring. Unlike with the adult patient, isolated significant microscopic hematuria defined as >50 red blood cells per high-powered field should prompt radiographic CT imaging (10,11). As stated earlier, the type of trauma (blunt versus penetrating), mechanism of injury (e.g., deceleration injury), physical examination (presence of a rib fracture or spinous process fracture, abdominal or flank tenderness, flank ecchymosis, etc.), and associated nonurologic injuries in hemodynamic stable children should all undergo radiographic CT staging of the renal injury.

If immediate laparotomy is required, a single-shot IVP should be performed in the operating room. A bolus IV injection of 2 mL per kg of radiographic contrast is given followed by a 10-minute plain film of the abdomen and pelvis. It is critical to document a functioning contralateral kidney should a nephrectomy be required of the injured renal unit. With a normal single-shot intraoperative IVP demonstrating two intact renal units and a nonexpanding retroperitoneal hematoma, exploration can be avoided (12).

MANAGEMENT

Management of the injured kidney is based on consideration of the patient’s mechanism of injury, hemodynamic stability, associated injuries, and accurate radiographic staging of the injury (1). The vast majority of blunt traumatic renal injuries are clinically insignificant. Fewer than 2% of patients with blunt renal trauma require renal exploration (1,2) (Fig. 12.1).

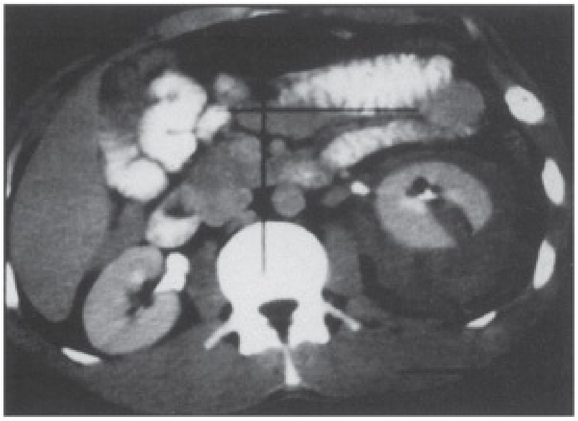

FIGURE 12.1 Abdominal computerized tomography (CT) reveals left renal laceration after blunt trauma (grade III). Even major renal lacerations occurring after blunt trauma are usually amenable to nonoperative management. Renal CT provides detailed information regarding the depth of laceration, size of perirenal hematoma, tissue viability, urinary extravasation, and status of the contralateral kidney.

Historically, all penetrating abdominal injuries underwent laparotomy. Now, with improved diagnostic radiographic imaging, many intra-abdominal and renal injuries can be staged and managed with nonoperative active surveillance combined with repeat imaging (5,13). If conservative management is chosen, it is the responsibility of the treating physician to document a stable or improving situation through clinical parameters and repeat imaging. All patients who sustain a major renal trauma and demonstrate stable hemodynamics should be admitted to the ICU for serial hematocrits, placed on bedrest, and have repeat CT imaging performed 48 hours after the initial staging CT scan or earlier if there is a significant change in their clinical course (5). Active surveillance ensures appropriate management either by demonstrating resolution of the renal injury or by prompting intervention, such as ureteral stent placement for nonresolving urinary extravasation or angioembolization of a segmental artery for persistent arterial extravasation (6,14,15). In all cases of severe renal injury, nonoperative management should only occur after radiographic CT renal staging in hemodynamically stable patients with close peritraumatic monitoring.

Urinary Stenting/Drainage

Urinary extravasation itself is not an indication for a urinary stent or percutaneous drainage. The need to intervene depends on the extent of urinary leakage, signs of infection (sepsis), and presence of a collecting system clot. If a large amount of urinary extravasation is seen, a repeat CT scan is recommended 48 hours after to assess if the urinary extravasation is improving. If the amount of urinary extravasation is decreasing and the patient shows no sign of infection, then continued observation is appropriate and the injury will likely resolve without intervention. If urinary extravasation is unchanged or worsening, then an attempt at a ureteral stent is recommended. If the fluid collection persists despite ureteral stent, a percutaneous drain can be placed to maximize drainage. Findings of a collecting system hematoma, fractured kidney, sepsis, and large segment of devascularized parenchyma (>25%) are more likely to require urinary stenting or percutaneous drainage (6).

Risk Factors for Hemodynamic Instability Intervention

A major reason that renal injuries continue to be explored is the presence of associated intra-abdominal injuries that require exploration. If a major renal injury is seen, this unfortunately often results in a nephrectomy (6). With proper and complete renal staging, renal exploration and thus nephrectomy can be avoided. Renal trauma patients that do undergo CT imaging in order to grade the degree of renal injury have certain CT imaging characteristics that can help predict the likelihood of an intervention. Parkland Hospital (Dallas, Texas) has identified three radiographic findings on CT imaging that predict the need for interventions for patients sustaining a blunt trauma injury: active vascular extravasation, perinephric hematomas >3.5 cm, and medial lacerations (16). Two centers looking to validate these radiographic predictors of intervention found that the presence of active intravascular extravasation and/or perinephric hematoma rim >3.5 cm on CT imaging increased the risk of intervention significantly. The location of the laceration was not found to be predictive of intervention individually (17,18). When all three risk factors are present, the likelihood of intervention varies from 50% to 67% (18). Likewise, patients with no high-risk criteria rarely require intervention (17).

ANGIOEMBOLIZATION

The minimally invasive technique of angioembolization along with radiographic CT imaging has led to a dramatic shift in trauma care in large urban centers where interventional radiology expertise is available. A clear role has emerged for selective segmental arterial embolization in a subset of severe renal injuries to control significant bleeding (19–21). Renal hilar injuries are life-threatening and require immediate operative exploration (22). As with all severe renal injuries, selection is critical for successful management, along with having available and capable interventional radiologists or trained vascular or trauma surgeons. Indications include non–life-threatening bleeding isolated to a segmental renal artery or vein in the setting of an expanding perirenal hematoma or refractory hypovolemia (>3 units of blood transfusion). The embolized vessel is typically a segmental artery, as venous bleeding will often tamponade provided Gerota fascia is still intact (Fig. 12.2). Embolization will lead to nephron loss and should be restricted to active arterial extravasation. Selective embolization has demonstrated excellent preservation of the remaining kidney for not only renal trauma injuries but also for symptomatic angiomyolipomas, spontaneous perirenal bleeds, pseudoaneurysms, and iatrogenic renal vascular injuries; this has resulted in shorter hospital stays, decreased pain, and fewer complications by avoiding open exploration (20,23,24). Endovascular procedures will continue to expand their role in the acute trauma setting as comfort and experience with these minimally invasive techniques grow.

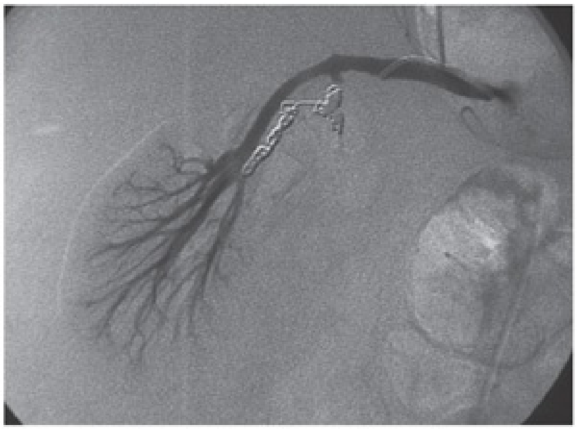

FIGURE 12.2 Angioembolization of active segmental arterial extravasation.

INDICATIONS FOR RENAL EXPLORATION

An absolute indication for renal exploration is life-threatening hemorrhage from a severely injured renal unit. Relative indications for operative exploration include ureteropelvic junction disruption, extensive nonviable renal parenchyma with urinary extravasation, incomplete radiographic staging, and limited observational facilities (Table 12.1). In the setting of a concomitant exploratory laparotomy by the trauma surgeons, our preference is to formally explore and reconstruct any significant renal injury (grade III or greater) in a hemodynamically stable patient. Minimal time is added to the operation, and outcomes are excellent (7). Successful reconstruction can be undertaken despite spillage from bowel injury, pancreatic injury, or other associated injuries (25).

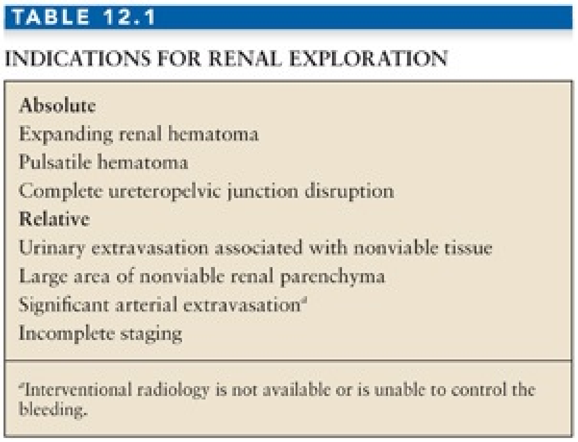

TABLE 12.1

INDICATIONS FOR RENAL EXPLORATION

Absolute
Expanding renal hematoma
Pulsatile hematoma
Complete ureteropelvic junction disruption
Relative
Urinary extravasation associated with nonviable tissue
Large area of nonviable renal parenchyma
Significant arterial extravasation[a]
Incomplete staging

[a] Interventional radiology is not available or is unable to control the bleeding.

In both blunt and penetrating isolated severe renal trauma (no other significant intra-abdominal injuries), selective management is employed to determine if exploration is indicated based on the hemodynamics of the patient, radiographic CT staging of the renal injury, and clinical assessment (5,26). In our large series of grade IV renal injuries, 28% were isolated kidney injuries, 42% underwent exploration, and the remaining 58% were managed nonoperatively. Persistent bleeding requiring multiple blood transfusions was the primary indication for renal exploration (average transfusion requirement of 8.5 U packed red blood cells [prbc]). Guidelines for intervention are hemodynamic instability causing severe hypotension and shock, a rapidly expanding renal hematoma, persistent hemodynamic instability despite 3 U prbc, and clinical decompensation (5). Renal salvage rates were high (>85%) for both operative and nonoperative management, demonstrating the use and importance of selective management.

NEPHRECTOMY

Nephrectomy should be reserved for critically ill patients during a damage control situation and/or renal pedicle avulsions that require complex vascular reconstruction. In these acute settings, it is critical to document a functioning contralateral kidney with a single-shot IVP. These patients are often in shock, have high injury severity scores, receive large volumes of blood transfusions, and overall experience a high mortality rate. As stated by Nash et al. (27), “It is not the exploration that results in the nephrectomy but the injury itself.”

SURGICAL TECHNIQUE

Renal exploration in the trauma setting should be carried out through a standard midline abdominal incision (Fig. 12.3). This approach provides complete access to the intra-abdominal viscera and vasculature and also gives the greatest flexibility to assess and repair a variety of genitourinary injuries. Major bleeding noted on opening the abdominal cavity should be controlled immediately with laparotomy packs followed by surgical control and repair. Associated injuries to other abdominal organs are usually addressed before examination of the kidneys if the patient is stable. The bowel, liver, spleen, pancreas, and other organs should be inspected systematically and carefully. During this period, Gerota fascia maintains its natural tamponade effect on the perinephric hematoma.

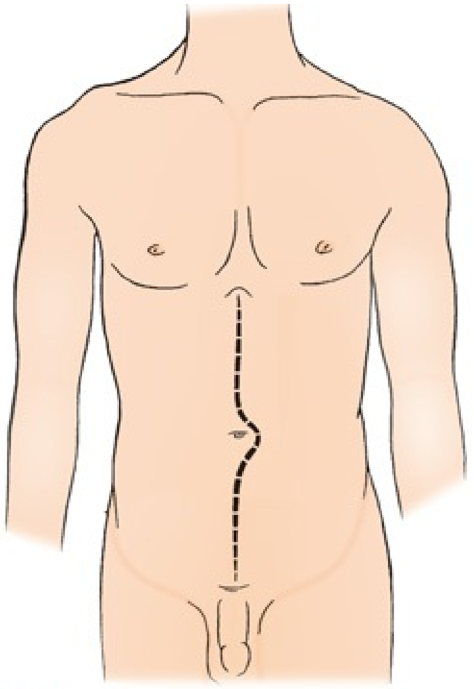

FIGURE 12.3 A midline incision provides the optimal exposure for abdominal exploration, vascular control, and repair of a variety of genitourinary injuries.

The renal vasculature is routinely isolated before entering the retroperitoneal hematoma surrounding the injured kidney. This reduces the risk of uncontrolled renal bleeding and unplanned nephrectomy (28,29). To facilitate access to the retroperitoneum, the transverse colon is lifted out of the abdomen superiorly and placed on moist laparotomy packs. The small bowel is rotated to the patient’s right and extracted from the body to allow access to the great vessels. An incision is made in the retroperitoneum over the aorta from the level of the inferior mesenteric artery to the ligament of Treitz, which can be divided for additional exposure. If a large retroperitoneal hematoma obscures the aorta, the inferior mesenteric vein is identified and the incision into the retroperitoneum is placed just medial to this important landmark. Once the aorta is identified in the lower part of the incision, it is followed superiorly to the left renal vein, which reliably crosses anteriorly. The renal arteries can be found just posterior to the left renal vein on either side of the aorta. The right renal artery can be isolated in the interaortocaval location. If it is difficult to identify the right renal artery through this approach, the second portion of the duodenum can be reflected to expose the right renal hilum. The artery is located posterior to the right renal vein.

The renal artery and vein associated with the injured renal unit are individually isolated with vessel loops. These vessels are not occluded initially unless uncontrollable bleeding is encountered. Most bleeding is successfully controlled with manual compression alone. Because the vessels are not routinely clamped, renal perfusion is continuous and warm ischemia is avoided.

Following proximal vascular control, the kidney is exposed by incising the retroperitoneum just lateral to the colon. The colon is reflected medially. Gerota fascia is sharply opened, and the kidney is expeditiously mobilized to allow complete exposure of the renal surface (Fig. 12.4). Only after complete exposure can the extent and number of injuries be determined (Figs. 12.5 and 12.6). Maintaining the renal capsule during mobilization is important as it provides hemostasis and tensile strength for the closure. If necessary for uncontrollable hemorrhage, clamping of the previously isolated vessels can be done with vascular clamps or bulldogs.

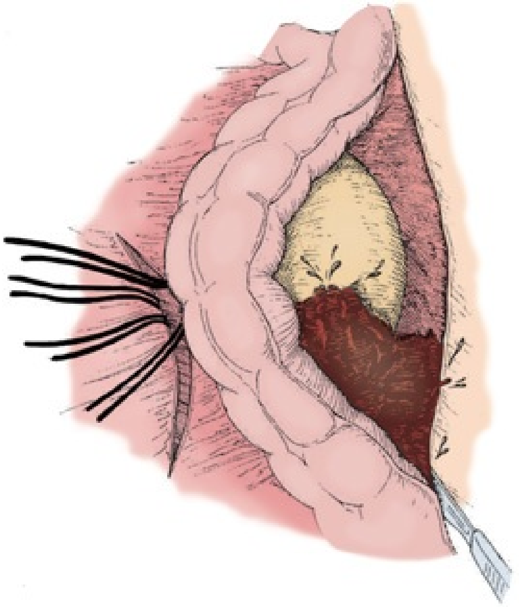

FIGURE 12.4 The colon is reflected medially to allow access to the retroperitoneum. Gerota fascia is sharply opened.

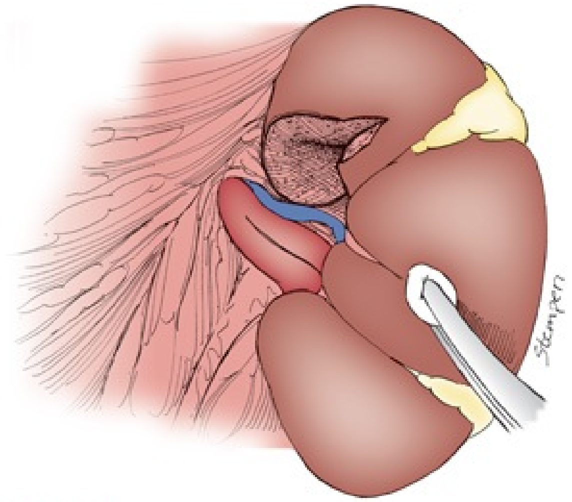

FIGURE 12.5 The kidney is explored. A small gunshot entrance wound on the anterior aspect of the left kidney is identified.

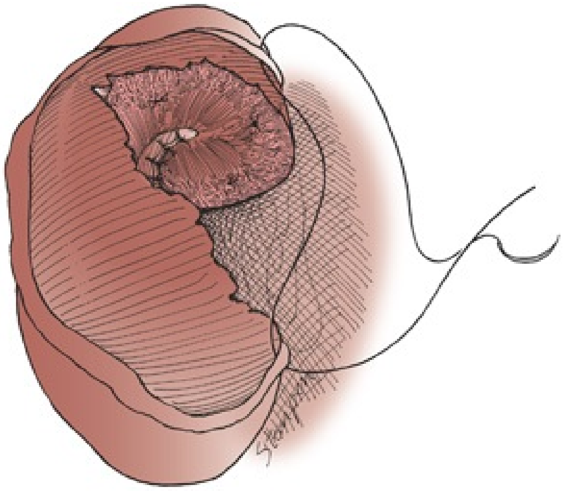

FIGURE 12.6 On the posterior surface of the same kidney in Figure 12.5, a complex gaping exit wound is identified. Nonviable tissue is sharply debrided, segmental vessels are individually suture-ligated, and the collecting system is closed with a continuous absorbable suture. Capsular 3-0 Vicryl sutures are used to reapproximate wound edges.

The following principles are applied to all renal reconstructions: early vascular control, complete renal exposure, sharp debridement of nonviable tissue, oversewing of bleeding vessels for hemostasis, and watertight collecting system closure. If available, the renal capsule is loosely reapproximated over thrombin-soaked Gelfoam or another thrombogenic substance. Ideally, an omental flap is placed over the reconstructed kidney for additional protection and its absorptive properties.

Major polar injuries are best approached by a polar partial nephrectomy. The kidney should be sharply debrided back to viable bleeding tissue. End vessels are individually suture-ligated with 4-0 absorbable sutures to gain hemostasis. The collecting system is then closed with a continuous watertight 4-0 absorbable suture. Methylene blue may be injected into the renal pelvis with simultaneous compression of the ureter to elucidate any leaks in the collecting system, which may then be oversewn; oversewing, however, is not routinely performed. The renal parenchymal defect is covered with thrombin-soaked Gelfoam or another thrombogenic bulking agent to enhance hemostasis and is covered with loosely approximated, interrupted 3-0 absorbable renal capsular sutures. If no capsule is available or the defect is too large to close primarily, an omental pedicle flap can be used to cover the defect (Fig. 12.7). Its absorbent properties and rich vascular supply make it an excellent alternative to the renal capsule. Another substance we commonly use to cover the renal defect is Vicryl mesh as it is readily available, absorbable, and can easily be tailored to the size and shape of the renal defect. A passive drain is placed and then removed in 48 to 72 hours after confirming closure of the collecting system.

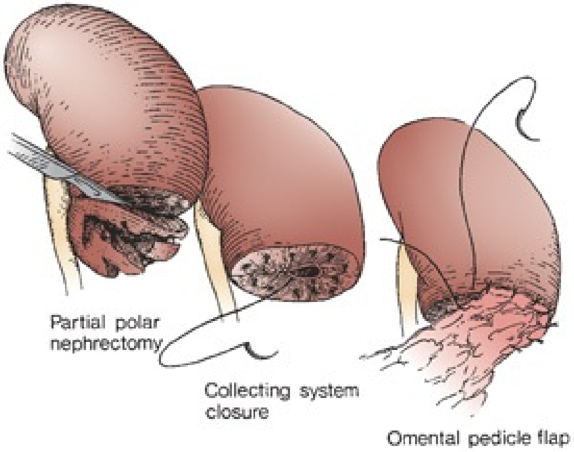

FIGURE 12.7 During a polar partial nephrectomy with reconstruction, if the renal capsule is not available for defect closure, a Vicryl mesh patch or the omentum can be used to cover the defect.

Major injuries to the midportion of the kidney are best repaired by sharp wedge resection of the nonviable tissue and renorrhaphy. Devitalized tissue is sharply removed. Sites of bleeding are individually ligated with fine absorbable sutures and the collecting system is closed with a continuous suture. Thrombin-soaked Gelfoam bolsters are placed into the defect to enhance hemostasis and reduce tension on the capsular sutures (Fig. 12.8). Interrupted absorbable 3-0 sutures are placed through the renal capsule, excluding the underlying parenchyma, as it provides no additional strength. Omentum or Vicryl mesh can be used if primary renal capsular closure cannot be achieved.

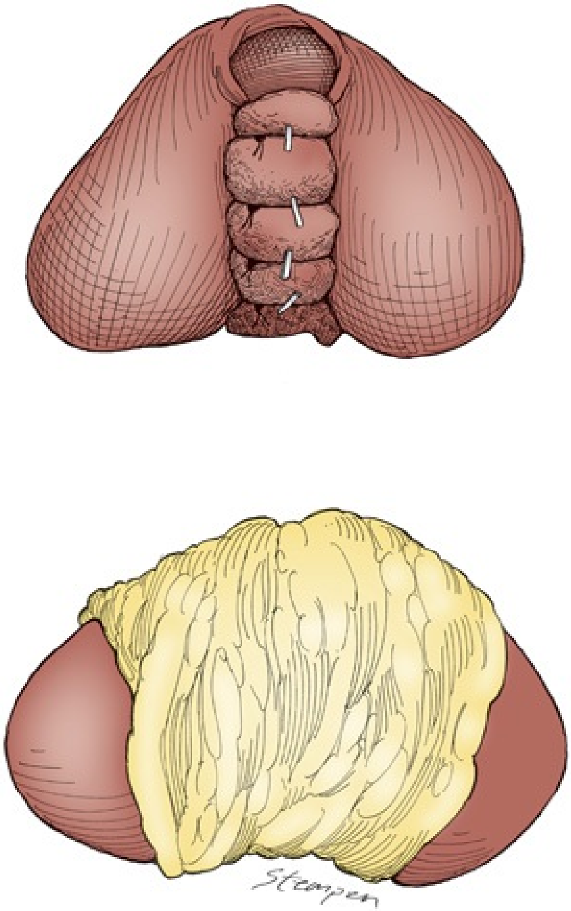

FIGURE 12.8 Closure of parenchymal defect after central renal injury. Capsular sutures of 3-0 Vicryl may be used to sew gelatin foam bolsters into the repair site. Titanium clips may be placed along the repair line to identify the area of reconstruction on subsequent imaging studies. Alternatively, if primary renal closure cannot be achieved, an omental flap may be tacked over the defect using small interrupted chromic sutures.

Renal stab wounds often do not result in displaced or missing renal tissue. Frequently, entrance and exit wounds can be oversewn, and liquid thrombogenic agents such as FloSeal can be applied, resulting in excellent hemostasis (Figs. 12.9 and 12.10). Collecting system injuries that may have occurred will usually resolve with closure of the overlying parenchyma and should not be aggressively pursued. If delayed urinary extravasation is detected by a perirenal drain or radiographic imaging, a ureteral stent can be placed with anticipated collecting system closure (5,14).

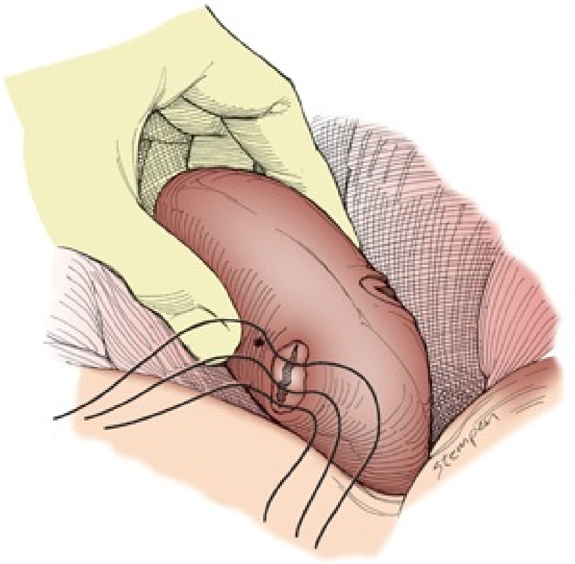

FIGURE 12.9 Technique of renorrhaphy after stab wound. Gelfoam bolsters are laid into the capsular defect, and overlying 3-0 Vicryl sutures are placed superficially to approximate the adjoining renal capsule, thus sealing the reconstructed area.

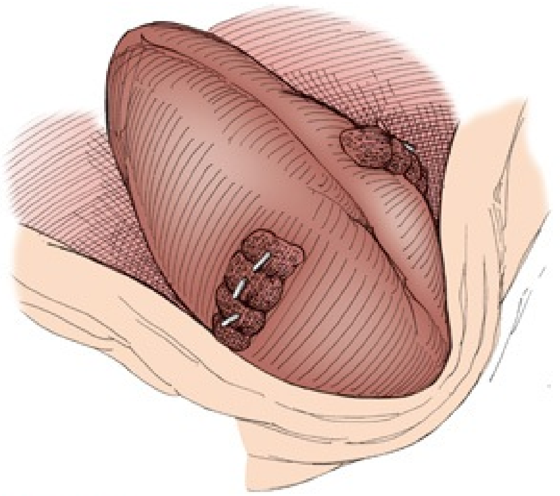

FIGURE 12.10 Completed renal reconstruction after stab wound. The entire kidney has been mobilized and evaluated for associated wounds. Titanium clips along the capsular sutures denote the area of repair.

RENOVASCULAR INJURIES

Renovascular injuries are closely associated to the grade of renal injury and are a major cause of partial or total renal loss. Main renal artery or vein avulsion, in the acute trauma situation, is deemed irreparable and results in nephrectomy. Proximal control of the renal pedicle is critical in these injuries to avoid life-threatening hemorrhage. Attempts at complex hilar arterial or venous reconstruction have shown poor results and should be reserved for the solitary kidney or bilateral renal hilar injuries in a non–damage-control situation (1,26,30). If necessary, the left main renal vein can be suture-ligated with sufficient drainage through the left adrenal and gonadal vessels. Reconstruction of a partial venous or arterial hilar injury can be performed with a continuous fine nonabsorbable suture after obtaining vascular control (Fig. 12.11).

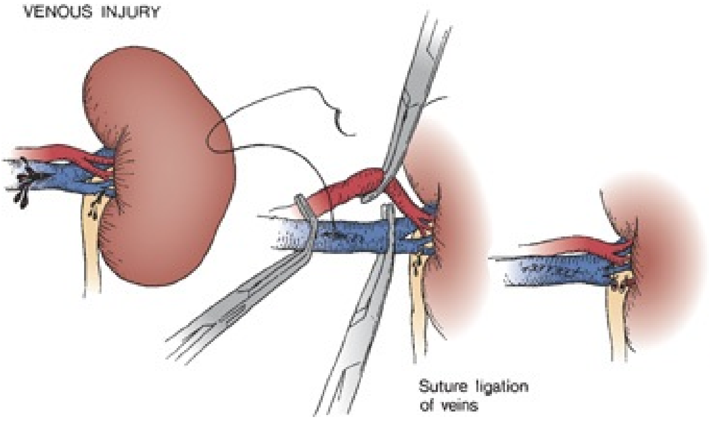

FIGURE 12.11 Repair of partial main renal vein or artery injury using a nonabsorbable continuous suture after gaining vascular control.

POSTOPERATIVE CARE

Gross blood in the urine usually clears within 24 hours, and patients should be observed on bedrest until this occurs. Ambulation is resumed once the urine is clear. Routine laboratory studies are obtained. In the event of a delayed bleed, renal angiography and selective angioembolization can be utilized to control the hemorrhage. Retroperitoneal drains are normally removed within 48 to 72 hours. If drainage is excessive, an aliquot may be checked for creatinine; a level similar to that of serum suggests peritoneal fluid rather than urine. All strenuous activity is suspended for a minimum of 3 months, at which time a radiographic CT imaging study is obtained to document complete renal healing. A radionuclide study can be obtained to assess renal function.

COMPLICATIONS

Delayed renal hemorrhage or development of an arteriovenous malformation (AVM) or pseudoaneurysm usually occurs in the acute peritrauma period and presents with flank pain and/or gross hematuria (cardiovascular issues may also develop with AVM). These situations are best managed by selective angioembolization, which is a safe and effective treatment modality. Mild to moderate urinary extravasation is rarely clinically significant and can be followed by repeat CT imaging to ensure resolution. Large urinomas can be treated with percutaneous drainage and may require a ureteral stent if repeat CT imaging demonstrates persistent or worsening urinary extravasation. Hypertension after renal trauma is classically associated with a Page kidney injury and is otherwise infrequent. Delayed nephrectomy or preferably, capsulectomy and drainage can successfully manage hypertension secondary to a Page kidney injury, as this is an anatomic compression of the renal parenchyma. Medical therapy is otherwise utilized as indicated for essential hypertension.

SUMMARY

Radiographic CT staging, improved endovascular minimally invasive techniques, and growing experience have allowed more successful nonoperative renal trauma care to occur. Although limited, the role for renal exploration still exists in critically ill patients with potentially life-threatening hemorrhage and in those who cannot be preoperatively staged by radiographic CT imaging and observed in ICUs. If renal exploration is necessary, early vascular control and adherence to reconstructive principles will ensure high renal salvage rates.

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CHAPTER 13 RENAL TRANSPLANTATION

JOHN M. BARRY

When compared to dialysis, kidney transplantation is the better treatment for patients with end-stage renal disease because of its survival advantage, less impairment with everyday living, and lower long-term treatment costs. Contraindications to kidney transplantation are considered to be unsuitable anatomy for technical success, active cancer, active infection, high probability of perioperative mortality, and inability to comply with a treatment plan. The transplant candidate selection process is performed well in advance of the transplant operation to be certain that those issues have been resolved. This process has been an example of interdisciplinary professional collaboration for decades. The kidney transplant operation is a demanding, open surgical procedure that requires knowledge of pelvic anatomy and attention to the technical details of vascular and urinary tract reconstruction.

PATIENT PREPARATION

In addition to the standard preoperative preparation for major surgery, determination of ABO donor–recipient compatibility, and negative lymphocytotoxic donor–recipient crossmatches, the following questions need to be addressed at the time of transplantation:

1. Will additional surgery, such as removal of one or both kidneys, removal of a chronic peritoneal dialysis catheter, or scar revision, be necessary?
2. Is the patient anuric, and will the bladder, reservoir, or urinary conduit need to be irrigated free of mucus and debris?
3. Is there an inflatable penile prosthesis reservoir that must be avoided during urinary tract reconstruction?
4. Are there scars, stomas, dialysis catheters, and/or feeding tubes that will influence surgical site selection?
5. Is there a lower abdominal bruit, decreased femoral or pedal pulses, or a lower extremity arteriovenous dialysis access fistula that will determine which iliac fossa should be used as the operative site?
6. Is the right or left kidney to be transplanted? (Transplantation of a kidney into the opposite iliac fossa is preferred because it will place the renal pelvis and proximal ureter medial and superficial to the vascular pedicle.)
7. Is the patient obese? (The iliac vessels are more superficial on the right than on the left).
8. Is there a central venous hemodialysis catheter in place? (The anesthetist will need to be reminded that each of the two limbs of a dialysis catheter contains concentrated heparin, which must be aspirated before an infusion is started.)
9. Does the patient have a clotting disorder that will require perioperative anticoagulation in addition to the standard recommendations for thromboembolism prevention?

COORDINATION WITH ANESTHESIOLOGY

An information sheet is popular with anesthesia teams (Table 13.1). It includes antibiotic choice, dosage and administration times of immunosuppressants, recommendations for diuresis promotion after renal revascularization, and goals for intravascular volume status and blood pressure.

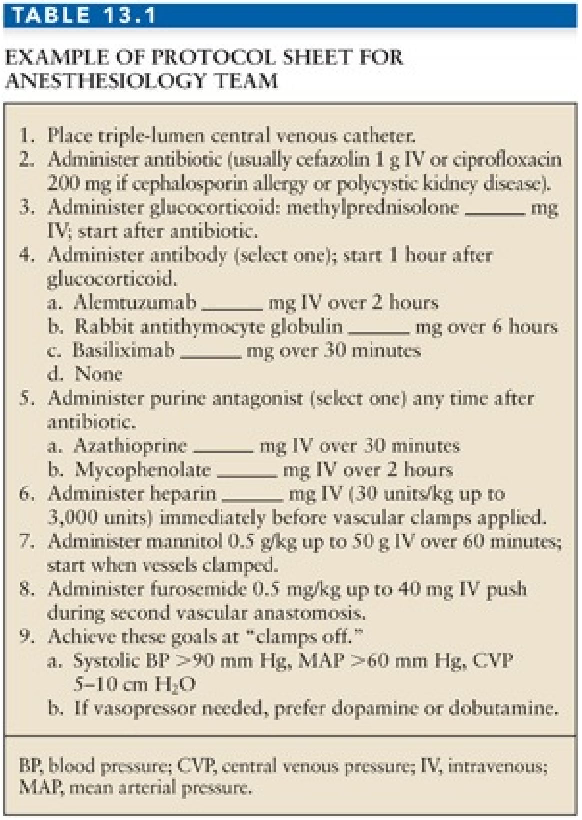

TABLE 13.1

EXAMPLE OF PROTOCOL SHEET FOR ANESTHESIOLOGY TEAM

1. Place triple-lumen central venous catheter.
2. Administer antibiotic (usually cefazolin 1 g IV or ciprofloxacin 200 mg if cephalosporin allergy or polycystic kidney disease).
3. Administer glucocorticoid: methylprednisolone ______ mg IV; start after antibiotic.
4. Administer antibody (select one); start 1 hour after glucocorticoid.
    a. Alemtuzumab ______ mg IV over 2 hours
    b. Rabbit antithymocyte globulin ______ mg over 6 hours
    c. Basiliximab ______ mg over 30 minutes
    d. None
5. Administer purine antagonist (select one) any time after antibiotic.
    a. Azathioprine ______ mg IV over 30 minutes
    b. Mycophenolate ______ mg IV over 2 hours
6. Administer heparin ______ mg IV (30 units/kg up to 3,000 units) immediately before vascular clamps applied.
7. Administer mannitol 0.5 g/kg up to 50 g IV over 60 minutes; start when vessels clamped.
8. Administer furosemide 0.5 mg/kg up to 40 mg IV push during second vascular anastomosis.
9. Achieve these goals at "clamps off."
    a. Systolic BP >90 mm Hg, MAP >60 mm Hg, CVP 5–10 cm H_2O
    b. If vasopressor needed, prefer dopamine or dobutamine.

BP, blood pressure; CVP, central venous pressure; IV, intravenous; MAP, mean arterial pressure.

SURGICAL TECHNIQUE IN ADULTS

The surgical technique for adults and large children will be described in detail because all variations are based on it (1). See Table 13.2 for items that should be quickly available to have a smooth operation. If present, the chronic peritoneal dialysis drain is opened to empty the abdomen of fluid and then closed. The urethral meatus or the urinary conduit stoma is prepped, and a three-way Foley catheter system is placed (Fig. 13.1). This is commonly done while the anesthesia team places a central venous access line. The urinary reservoir or conduit is irrigated with an antibiotic solution, the outflow tube is clamped, and this is placed at the head of the table so the anesthetist can fill and drain the urinary system during the case. This can be helpful when differentiating the bladder, urinary conduit or urinary reservoir from surrounding scar tissue, or an inflatable penile prosthesis reservoir. Adhesive residue, common on the abdomen of patients who undergo peritoneal dialysis, should be removed. The skin of the abdomen and any abdominal tubes are washed with alcohol and painted with an antiseptic skin preparation. The patient is draped so there is surgical access to the entire abdomen in case the selected site turns out to be unsuitable during exposure of the targeted blood vessels.

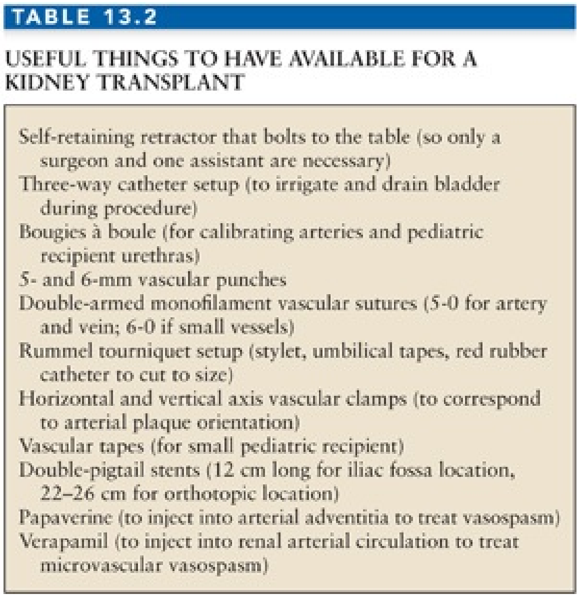

TABLE 13.2

USEFUL THINGS TO HAVE AVAILABLE FOR A KIDNEY TRANSPLANT

Self-retaining retractor that bolts to the table (so only a surgeon and one assistant are necessary)
Three-way catheter setup (to irrigate and drain bladder during procedure)
Bougies à boule (for calibrating arteries and pediatric recipient urethras)
5- and 6-mm vascular punches
Double-armed monofilament vascular sutures (5-0 for artery and vein; 6-0 if small vessels)
Rummel tourniquet setup (stylet, umbilical tapes, red rubber catheter to cut to size)
Horizontal and vertical axis vascular clamps (to correspond to arterial plaque orientation)
Vascular tapes (for small pediatric recipient)
Double-pigtail stents (12 cm long for iliac fossa location, 22–26 cm for orthotopic location)
Papaverine (to inject into arterial adventitia to treat vasospasm)
Verapamil (to inject into renal arterial circulation to treat microvascular vasospasm)

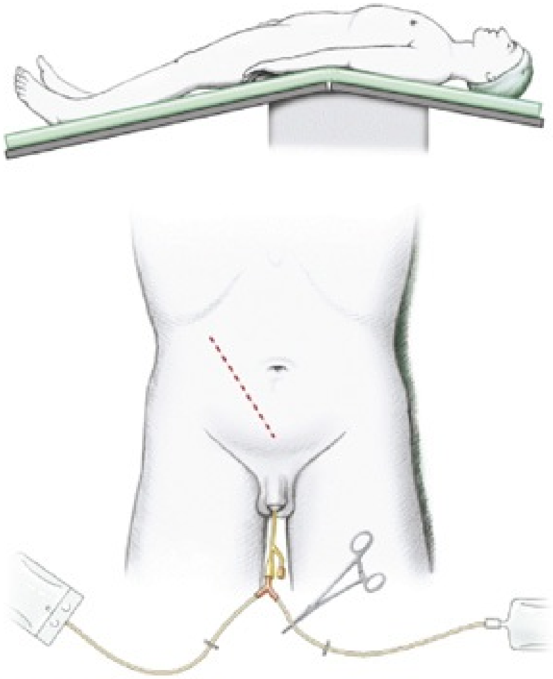

FIGURE 13.1 Patient position, incision site (*dotted line*), and three-way bladder infusion–drainage setup. (Reprinted with permission from Barry JM. Renal transplant recipient surgery. *BJU Int* 2007;99:701–717. Copyright © 2007, John Wiley and Sons.)

Incision and Iliac Fossa Dissection

A Gibson or Rutherford Morison incision from pubic notch toward the costal margin where it intersects the anterior axillary line is common. The anterior rectus sheath is incised, and the underlying rectus muscle is preserved; it will be retracted medially. The quality of the deep fascia and muscles can be judged during the incision, and a decision made about the type of suture material and whether an interrupted or running closure of the deep wound will be done.

After the inferior epigastric vessels are divided between ligatures, an index finger can be used to develop the plane between the partially filled bladder and the iliac vessels. If the kidney transplant has a separate lower pole artery, the inferior epigastric artery is left long in case it is needed to revascularize the inferior renal segment (Fig. 13.2).

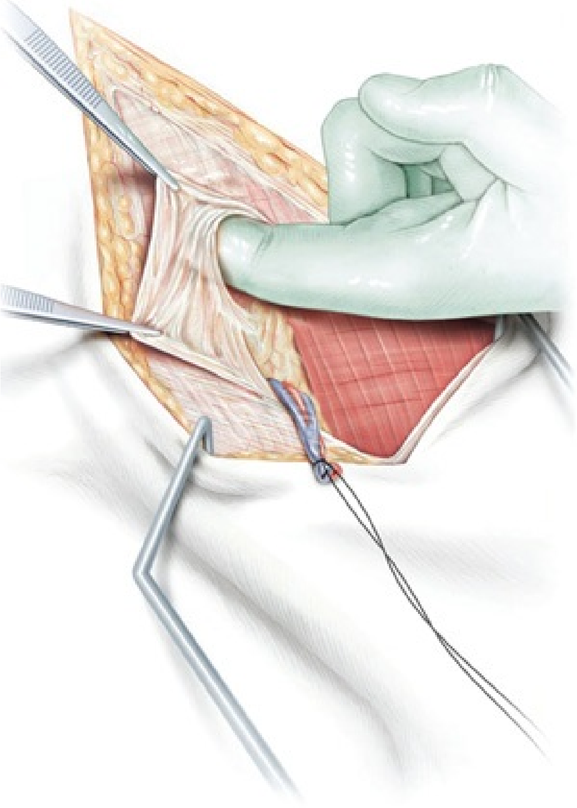

FIGURE 13.2 Development of extraperitoneal space after ligation and division of inferior epigastric vessels. (Reprinted with permission from Barry JM. Renal transplant recipient surgery. *BJU Int* 2007;99:701–717. Copyright © 2007, John Wiley and Sons.)

Rotating the finger upward between the transversalis fascia and the spermatic cord or round ligament will allow the development of the extraperitoneal space. The peritoneal edge is commonly adherent to the lateral edge of the posterior rectus sheath. In a woman, the round ligament is divided between ligatures; in a man, the spermatic cord is preserved and retracted medially. The iliac fossa is developed. Insertion of the first two fingers will identify a "ligament" that attempts to hold the peritoneum in the iliac fossa. Cut this and develop the space. Be careful not to damage the genitofemoral or ilioinguinal nerves. The ureter will naturally cling to the peritoneum. Continue to develop the extraperitoneal space until the index finger of the dissecting hand rests on the sacral promontory just above and medial to the bifurcation of the common iliac artery. Attach the post of the self-retaining retractor to the table, attach the retractor ring, and place the first of the padded retractor blades just medial to the sacral promontory. Place the rest of the retractor blades; it usually takes a total of five. Make certain that a retractor blade does not rest on the psoas muscle and compress the femoral nerve. If the bladder is full, have the anesthetist unclamp the drainage tube to give more space. Palpate the iliac arteries to determine where and what type of vascular clamps can be safely applied and the probable site of the renal artery anastomosis. Iliac arteriosclerosis commonly starts posteriorly at the takeoff of the internal iliac artery.

Dissect the iliac arteries (Fig. 13.3). Watch out for the genitofemoral nerve, which sometimes crosses the external iliac artery, is mistaken for a lymphatic, and divided between ligatures. Lymphatics are best ligated and divided. Clips are sometimes dislodged with the suction device later in the case. If the internal iliac artery has been selected for revascularization of the kidney, dissect it and the common iliac artery so that vascular clamps will be placed on the common and external iliac arteries and not the base of the internal iliac artery. This is to prevent vascular clamp injury to the internal iliac artery. Dissect the external and common iliac arteries. Division of the gluteal and internal iliac veins will allow the external iliac vein to be retracted anteriorly with Rummel tourniquets. This will permit the lateral venous suture line to be easily done from outside the vessels because when the iliac vein is deep and immobile, the lateral side of the anastomosis sometimes has to be done from inside the lumen, and this may leave a ridge and contribute to renal vein thrombosis.

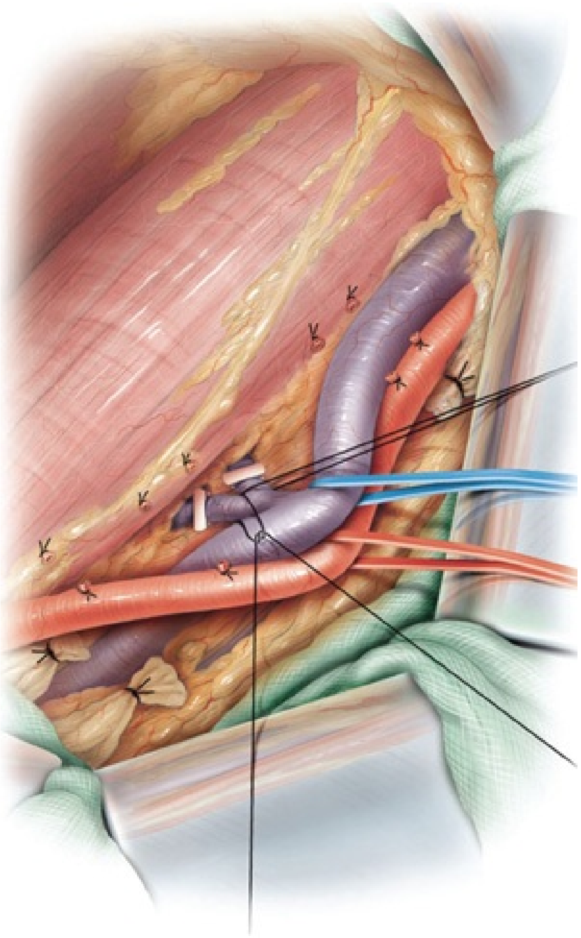

FIGURE 13.3 Dissection of iliac vessels and mobilization of external and common iliac veins. (Reprinted with permission from Barry JM. Renal transplant recipient surgery. *BJU Int* 2007;99:701–717. Copyright © 2007, John Wiley and Sons.)

If the kidney graft has not been prepared at the back table, do it now. If the kidney is from a living donor, it will be without an aortic patch, and the renal artery is commonly spatulated. If there are multiple renal arteries, and they are close together, they are usually joined together to make a common lumen (Fig. 13.4). A deceased donor kidney usually has its renal artery or arteries on an aortic patch, and the patch is used for the arterial anastomosis. If there are two separate veins of equal size in a living donor kidney, they are often joined, pair-of-pants fashion, to make a common lumen. If one is smaller than the other, it can be safely ligated. The right deceased donor kidney usually has the inferior vena cava (IVC) attached to it. It can be reconfigured in several different ways to extend the length of the short right renal vein (Fig. 13.5).

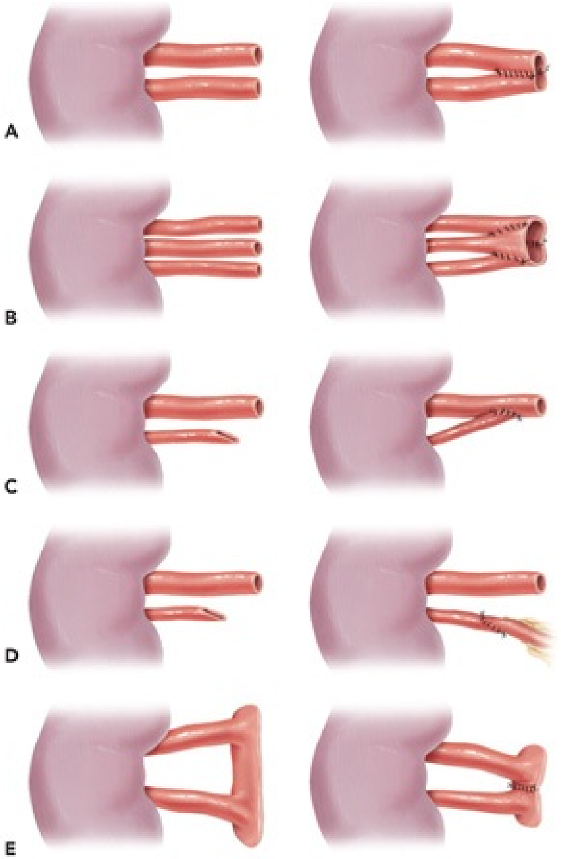

FIGURE 13.4 Options for renal artery reconstruction. (A) shows a "pair-of-pants" arterioplasty with two arteries. (B) shows the same concept with three arteries. (C) shows anastomosis of a lower pole artery to the main renal artery. (D) uses the recipient's inferior epigastric artery. (E) shows segmental aortectomy technique to make the aortic patch smaller in a deceased donor kidney transplant. (Reprinted with permission from Barry JM. Renal transplant recipient surgery. BJU Int 2007;99:701–717. Copyright © 2007, John Wiley and Sons.)

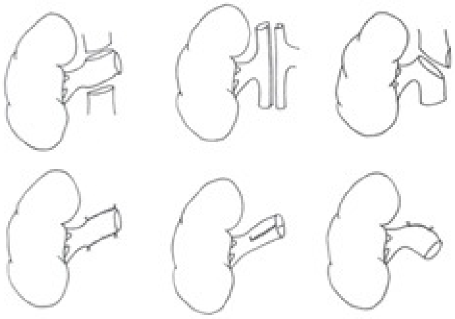

FIGURE 13.5 Three simple methods to lengthen a short right renal vein in a kidney from deceased donor.

Kidney Graft Position and Vascular Anastomoses

Place the kidney into the wound to determine the best fit and to select the sites of the arterial and venous anastomoses (Fig. 13.6). Remove the kidney and replace it in the cold slush–filled pan.

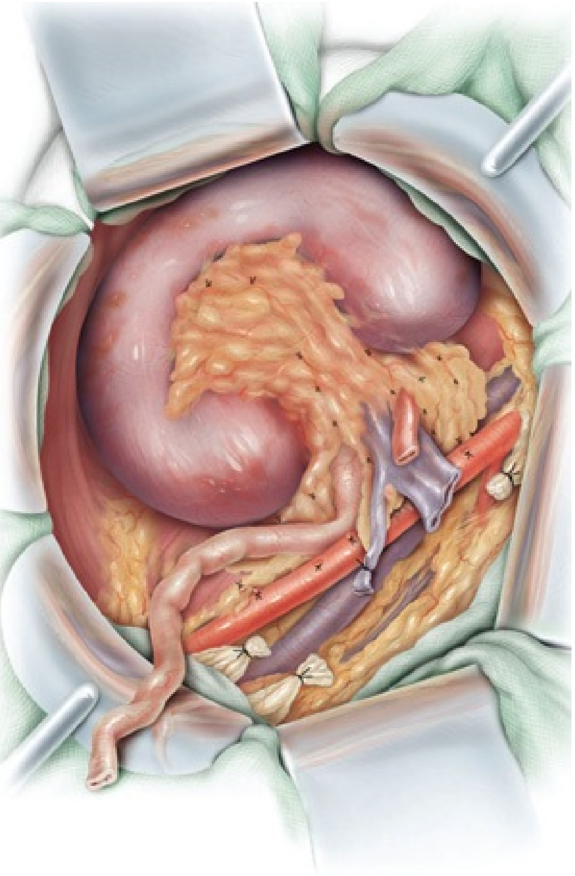

FIGURE 13.6 Placement of kidney transplant into wound to select recipient artery and vein for revascularization. (Reprinted with permission from Barry JM. Renal transplant recipient surgery. *BJU Int* 2007;99:701–717. Copyright © 2007, John Wiley and Sons.)

Check with the anesthetist and determine the status of the administration of the immunosuppressants. Ask for the heparin to be administered. A minute later, apply the arterial clamps. If there is a plaque in a vertical or lateral plane, use a vascular clamp with jaws that correspond to that plane. This is to reduce the risk of a plaque fracture and dissection. It seems preferable to do the arterial anastomosis first because it is the smaller of the two vascular anastomoses and the kidney is relatively mobile while it is being done. (If the venous anastomosis is done first, the kidney becomes fixed in position, the lateral half of the arterial anastomosis sometimes has to be done from inside the vessels, and a ridge from the arterial suture line ridge is more likely to result.) If the common iliac artery is the target, vascular clamps are placed in the common, external and internal iliac arteries, especially if the common iliac artery is relatively short. If the external iliac artery is the site, the clamps can be placed wherever it results in enough room to do the anastomosis. When the kidney is without an aortic patch, and there is to be an end-to-side anastomosis, make a 5- to 6-mm incision in the target artery with a no. 11 blade and enlarge the arteriotomy with a 5- or 6-mm punch; punch size will depend on the diameter of the donor artery. An aortic patch is common when the kidney is from a deceased donor. In such a case, it is not necessary to use a vascular punch in the recipient artery because the renal artery ostium in the donor aortic patch will hold the incised recipient artery open in the event of hypotension. If the internal iliac artery is to be used, place the vascular clamps in the external and common iliac arteries, ligate the internal iliac artery distally, divide it, spatulate it in its anterior surface, and flush it with heparinized saline. If there is a plaque, do an endarterectomy, release the common iliac vascular clamp to flush the lumen, reapply the clamp, and reflush the internal iliac artery with heparinized saline.

Wrap the kidney in a cold sponge or place it in a surgical glove, cut out one of the fingers, pull the vessels through the hole, and put some ice chips in the glove. Place the kidney in the wound.

Do the arterial anastomosis using the quadrant technique (Fig. 13.7). An experienced surgeon will sometimes use a single suture and tie it once at the completion of the anastomosis. At the start of the first anastomosis, ask the anesthetist to start the mannitol infusion.

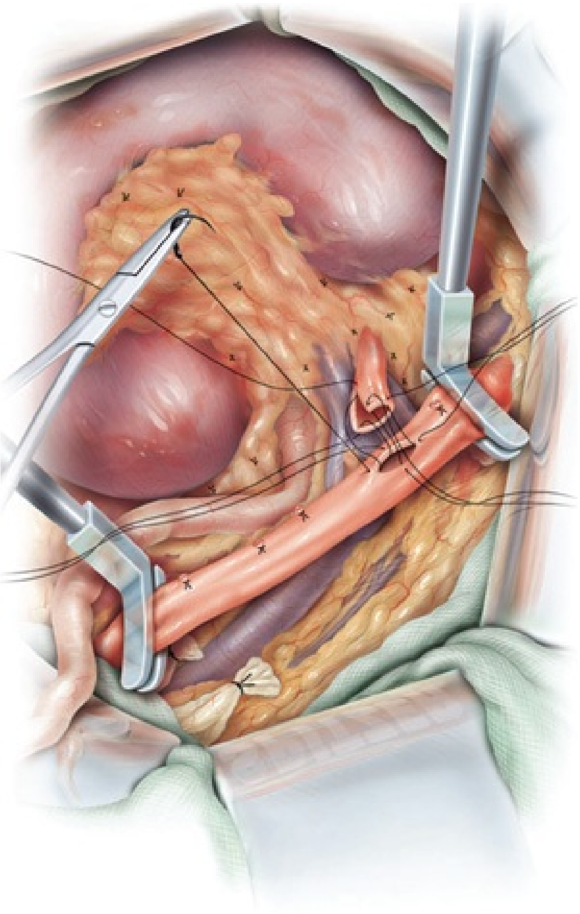

FIGURE 13.7 Renal artery anastomosis after 6-mm vascular punch arteriotomy. Quadrant technique is illustrated. (Reprinted with permission from Barry JM. Renal transplant recipient surgery. *BJU Int* 2007;99:701–717. Copyright © 2007, John Wiley and Sons.)

After the arterial anastomosis is finished, lay the kidney on its side and see where the venous anastomosis should be. Tighten the Rummel tourniquets, incise the vein, and place double-armed vascular sutures in either end of the venotomy and half-length sutures at the halfway points on either side such that the needles are on the inside (Fig. 13.8). Place the previously placed stay sutures inside-out in the renal vein and do the anastomosis, first one side and then the other. When the venous anastomosis is almost done, ask the anesthetist to administer the furosemide.

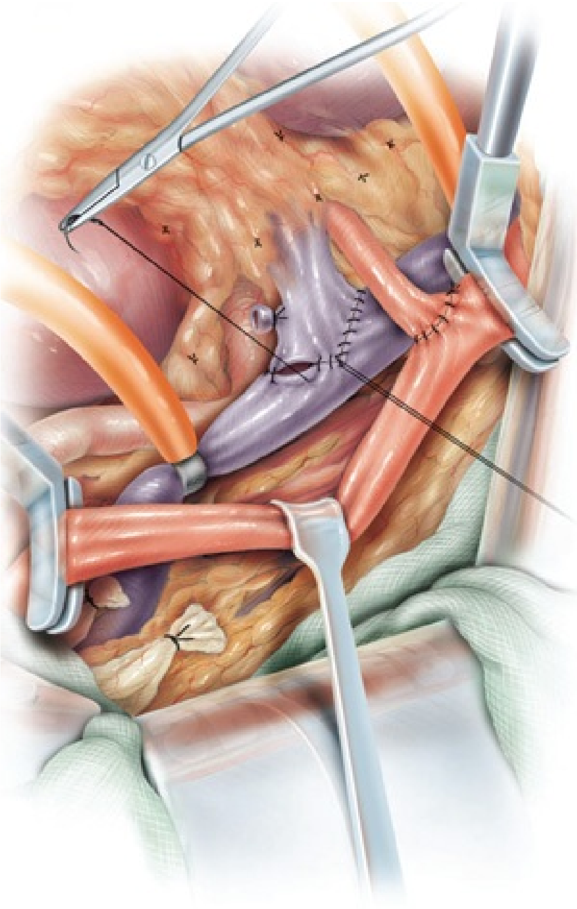

FIGURE 13.8 Renal vein anastomosis to junction of external and common iliac veins. (Reprinted with permission from Barry JM. Renal transplant recipient surgery. *BJU Int* 2007;99:701–717. Copyright © 2007, John Wiley and Sons.)

Remove the vascular tapes and clamps in the following order: proximal vein, distal artery, proximal artery, and distal vein. Put a dry sponge over both anastomoses and let the suture lines adjust. Take a peek after a minute or so and, if necessary, develop a plan for active bleeders. Renal perfusion can be increased by temporarily occluding the external iliac artery distal to the anastomosis. Vasospasm can be treated with the injection of papaverine into the adventitia of the renal artery. If renal microperfusion is of concern, verapamil can be injected into the lumen of the renal artery. When the heparin wears off and the bleeding is controlled, it is time to do the urinary tract reconstruction.

Urinary Tract Reconstruction

Urinary tract reconstruction is usually by extravesical ureteroneocystostomy (Figs. 13.9 to 13.11) (1,2), preferably with a submucosal tunnel to prevent reflux pyelonephritis in the event of a lower urinary tract infection. With either a parallel- or single-incision bladder technique, it is important to anchor the toe of the transplant ureter to the full thickness of the bladder to prevent sliding of the ureter in the submucosal tunnel and loss of the antireflux mechanism. Double ureters are made into one with the "pair-of-pants" technique, the same as for joining two arteries together. Use of a double-pigtail stent, or stents in the case of two ureters, is a matter of surgeon preference. Most agree that a stent will result in a lower incidence of urinary leakage or obstruction (3), but at the risks of increased urinary infection and voiding dysfunction, the latter because of bladder irritation from the distal curl of the stent. A 12 cm × 5Fr is commonly used. The integrity of the ureteroneocystostomy can be checked by filling the bladder through the three-way catheter system and looking for a leak.

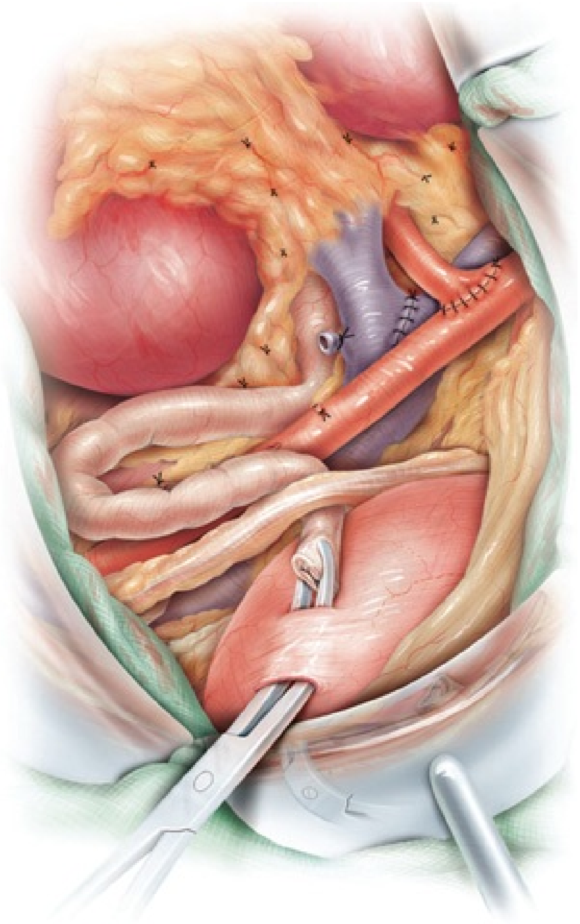

FIGURE 13.9 Completed renal revascularization. The kidney transplant ureter is brought under the spermatic cord and through the submucosal tunnel. (Reprinted with permission from Barry JM. Renal transplant recipient surgery. *BJU Int* 2007;99:701–717. Copyright © 2007, John Wiley and Sons.)

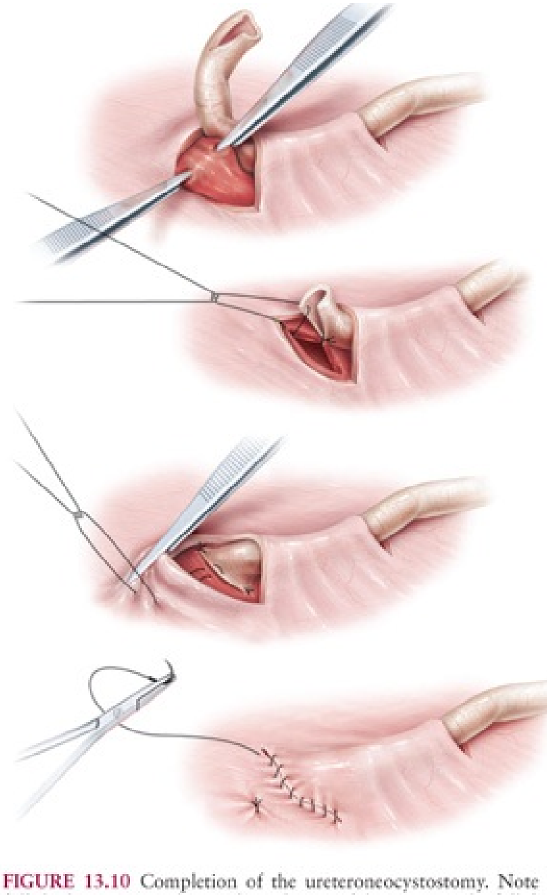

FIGURE 13.10 Completion of the ureteroneocystostomy. Note the full-thickness suture that anchors the toe of the ureter to the full thickness of the bladder. (Reprinted with permission from Barry JM. Renal transplant recipient surgery. *BJU Int* 2007;99:701–717. Copyright © 2007, John Wiley and Sons.)

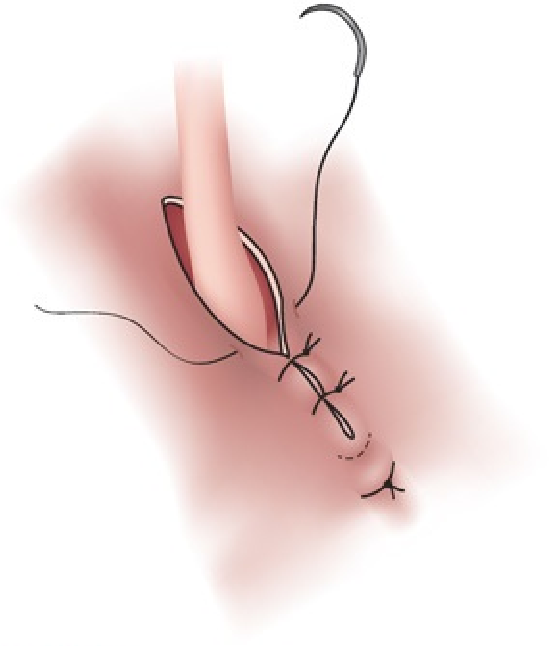

FIGURE 13.11 Single incision extravesical ureteroneocystostomy with full-thickness toe stitch.

The common alternate methods of urinary tract reconstruction are anastomosis of the transplant ureter to the ipsilateral native ureter and anastomosis of the transplant renal pelvis to the native ureter; both of which are usually done around a double-pigtail ureteral stent. The posterior suture line is completed first, the stent passed, and the anterior suture line is completed. Position of the distal curl can be confirmed to be in the bladder by having the anesthetist clamp the bladder catheter's drainage tube and fill the bladder through the three-way system. The recipient ureter need only be longitudinally incised, not ligated and transected. This prevents hydronephrosis of the native kidney if it still makes urine and preserves proximal native ureteral blood supply for the reconstruction.

Anastomosis of the kidney transplant ureter to an intestinal conduit is facilitated by passing a Foley catheter with the tip cut off into the base of the conduit and palpating the balloon through the intestinal wall (Fig. 13.12) (4). An enterotomy is made over the tip of the catheter, a guide wire passed through the enterotomy into the spatulated ureter. A double-pigtail stent is passed over the wire, and the wire is withdrawn to leave curls in the renal pelvis and the conduit. The catheter can be connected to drainage or removed. If the distal curl is left inside the conduit, the stent is less likely to be accidentally removed when the urostomy bag is changed.

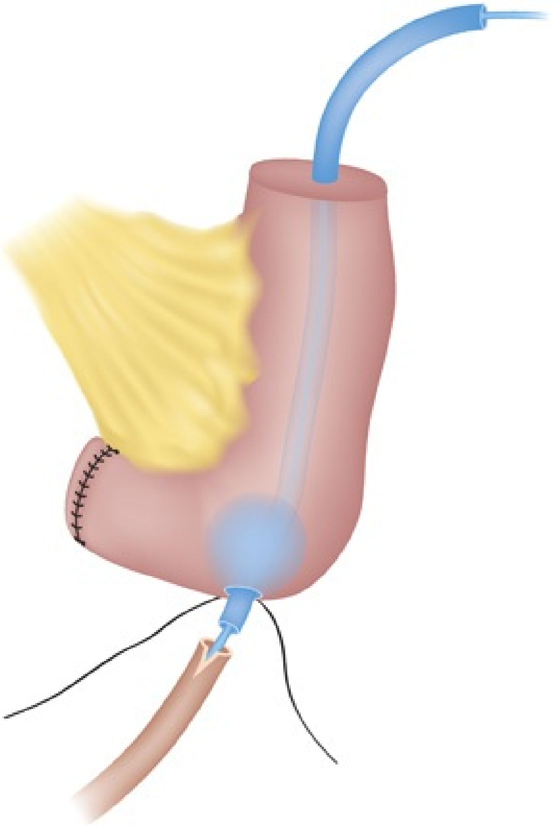

FIGURE 13.12 Urinary tract reconstruction into intestinal segment or pouch. A double-pigtail stent is usually inserted over the wire.

Wound Closure

Different opinions about wound closure and drainage are common. It is usually better to remove a drain than wish you had put one in. If used, a suction drain is placed in the wound, tip by the bladder, midportion just anterior to vascular anastomoses, and the rest curled up over the upper pole of the kidney transplant.

Two 36 inches 0 or no. 1 polyglyconate or polydioxanone running sutures, the first in the transversus and internal oblique muscles and the second in the anterior rectus sheath and the external oblique, will provide an adequate closure for most patients. If the patient is thin, bury the knots. If the deep fascia and muscle are of lesser quality, a wound closure with interrupted sutures with one of the same materials is reasonable. A far-far, near-near, figure-of-eight stitch tied with three knots: two surgeon's knots and a simple knot, all tied flat, one on the other, will not slip. If the patient is obese, a second drain under Scarpa fascia will drain a potential seroma. Scarpa fascia is closed with a running, 3-0 absorbable suture, and the skin is closed with a running subcuticular absorbable suture. This eliminates the need for skin suture or clip removal and is more comfortable for the patient.

Times of bladder catheter, drain and stent removal vary among surgeons. Usually, the bladder catheter can be removed on postoperative day (POD) 3 if the urinary output is less than 3 L per day, or on POD 5 if it is more than that. If there is concern about the possibility of a urine leak, the catheter is left indwelling and a cystogram done to confirm integrity of the urinary tract before catheter removal. If the recipient is a man older than 50 years, it is reasonable to give him a single oral dose of a selective alpha blocker at the time of catheter removal to prevent urinary retention, and it is always a good idea to do postvoid residual urine determinations by ultrasound for the first two or three voids. If a stent was placed, it is usually removed within 6 weeks of transplantation. If it had been attached to the bladder catheter at the time of ureteroneocystostomy, it will come out when that catheter is removed. The drain(s) is (are) usually removed when the 24-hour drainage is <50 mL. If the peritoneum had been entered during the case, a more liberal criterion is used.

Less Frequently Used Kidney Transplant Procedures

Orthotopic Kidney Transplantation

This is usually done when both iliac fossas are unsuitable because of prior surgeries or vascular disease. The usual target vessels in the recipient are the splenic artery and the left renal vein (Fig. 13.13) (5). The left native kidney and splenic artery can be approached through a vertical midline abdominal incision, a left Rutherford Morison incision that has been extended to the left costal margin, or a flank incision. The splenic artery is dissected to the hilum of the spleen, a vascular clamp is applied, and the splenic artery is ligated distally and divided. A splenectomy is not necessary because the short gastric arteries will supply that organ. A left nephrectomy is done after the renal artery has been ligated, and a vascular clamp has been placed on the renal vein. The adrenal and gonadal veins are usually divided between ligatures. The native ureter is divided close to the ureteropelvic junction, and the kidney is removed. The kidney transplant is placed in the wound to determine where it will best fit and how the hilar structures are to be oriented for reconstruction. The renal artery and the splenic artery are spatulated, flushed with heparinized saline, and an end-to-end anastomosis is done. The renal veins are anastomosed to one another, and a ureteroureterostomy or ureteropyelostomy, as described earlier, is done over a stent. Stent placement in the bladder can be confirmed by having the anesthetist clamp the bladder drainage tube and fill the bladder while the surgeon checks for reflux out the holes in the proximal stent curl. Stent length can be estimated from the patient’s height: 22 cm for patients <5 ft 10 inches, 24 cm for patients 5 ft 10 inches to 6 ft 4 inches, and 26 cm for patients >6 ft 4 inches (6).

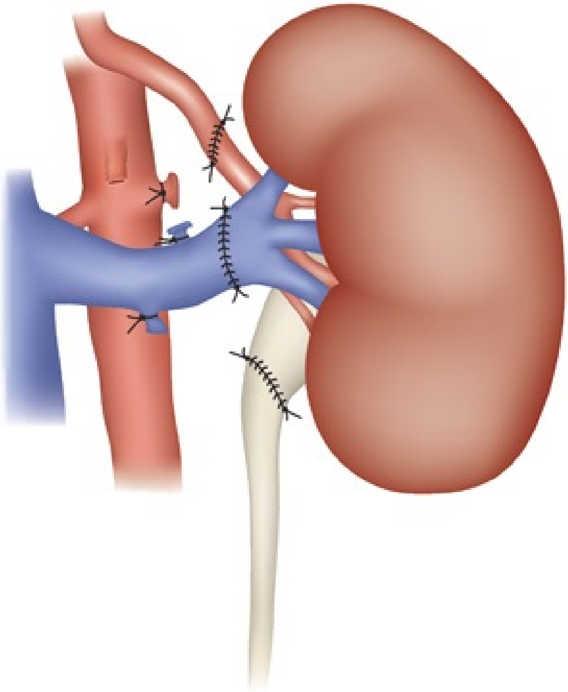

FIGURE 13.13 Orthotopic kidney transplant with splenic artery to renal artery and renal vein to renal vein anastomoses. Urinary tract reconstruction is by stented pyeloureterostomy or ureteroureterostomy.

En Bloc Kidney Transplantation

When two small kidneys from a deceased pediatric donor are transplanted into an adult, an en bloc procedure is usually done (7). Most commonly, the cut cephalic ends of the donor aorta and IVC are closed, and the distal ends of the aorta and IVC are anastomosed to the sides of the external iliac artery and vein, respectively (Fig. 13.14). Other methods of revascularization are anastomosis of the proximal aorta to the internal iliac artery after closure of the distal aorta, longitudinal splitting of the aorta and anastomosis of the aortic patch to the external iliac artery, and interposition of the donor aorta after excision of a section of the recipient's external iliac artery. The ureters are implanted separately or joined together and implanted in a common submucosal tunnel. Ureteral stents are commonly used.

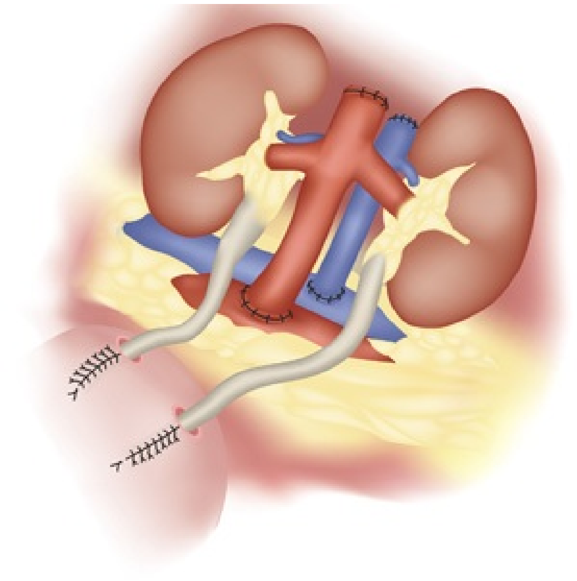

FIGURE 13.14 En bloc transplantation of pediatric kidneys onto the external iliac artery and vein.

Dual Kidney Transplantation

Deceased donor kidneys of poor quality that would prevent their transplantation as separate units are sometimes both transplanted into the same recipient. Each marginal kidney can be transplanted into each iliac fossa, or both can be transplanted, one cephalad to the other, into one iliac fossa and distal retroperitoneum (Fig. 13.15) (8,9). It is easier to do this on the right side.

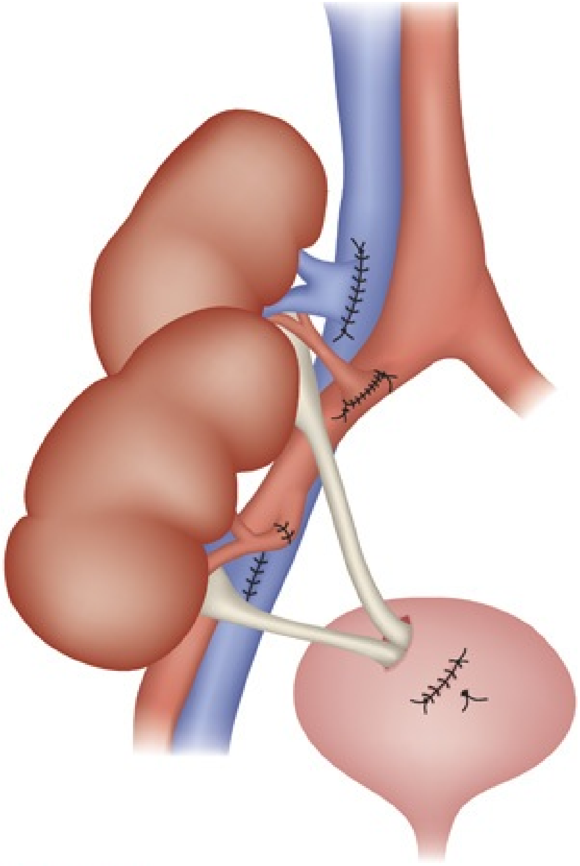

FIGURE 13.15 Dual transplantation of marginal deceased donor kidneys, one on top of the other. Illustrated vascular targets are the IVC and common iliac artery for the upper kidney and the internal iliac artery and external iliac vein for the lower one. The ureters have been joined so they can be implanted through a single submucosal tunnel.

SURGICAL TECHNIQUE IN SMALL CHILDREN

Adult kidneys are transplanted into small children (7). The urethra is calibrated with bougies, and the correctly sized Foley catheter is selected, inserted, and hooked to the three-way system, just as described for the adult recipient. The bladder is irrigated with the antibiotic solution. Placement of a central line, management of abdominal tubes, and skin preparation are the same as for the adult. If additional surgeries, such as a contralateral nephrectomy or bilateral nephrectomies are to be done under the same anesthetic, a vertical midline incision with a transperitoneal approach to the great vessels is usually done (Fig. 13.16). The IVC is exposed to the level of the renal veins, and both common iliac veins are dissected. The right common iliac vein may need to be completely exposed if the renal vein anastomosis will be long enough to require it and the IVC. The aorta, inferior mesenteric artery, and both common iliac arteries are exposed. The middle sacral and lumbar arteries are divided between ligatures. The recipient venous anastomotic target is isolated between Rummel tourniquets on the proximal IVC and common iliac veins, and the aorta, inferior mesenteric artery, and common iliac arteries are encircled with vascular tapes. Some surgeons prefer to use a vascular clamp on the proximal aorta. The previously prepared kidney is held up to drain the preservation solution, which contains high levels of potassium, and placed in the wound to select the sites for the venous and arterial revascularization. The usual targets are the IVC (and sometimes the right common iliac vein) and the aorta (and sometimes the right common iliac artery). Remove the kidney and, if necessary, shorten the renal artery and/or renal vein to assure a good fit without vessel kinks. The relatively large adult kidney has been drained of blood and preservation solution, and at the time of revascularization in a small child, it has to fill with blood from the child's circulatory system. This results in the acute blood loss of 50–100 mL into the kidney transplant. After tightening the clamps and/or tapes, use a 5- or 6-mm vascular punch on the aorta or common iliac artery, so that if hypotension ensues, the new renal artery ostium will not close and result in renal artery thrombosis. Irrigate the lumen with heparinized saline and do the arterial anastomosis as previously described. Tighten the Rummel tourniquets, incise the IVC and, if necessary, the right common iliac vein, irrigate the lumen, and do the venous anastomosis as described for the adult procedure (Fig. 13.17). Ask for the furosemide to be administered.

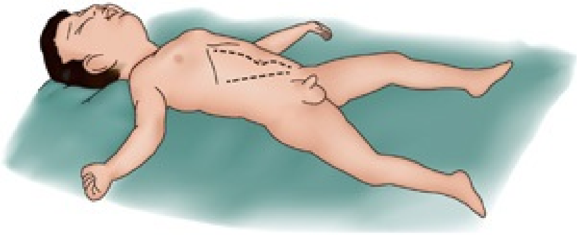

FIGURE 13.16 Incision options for transplantation of an adult kidney into a small child. The midline incision is usually chosen when other surgeries are to be undertaken under the same anesthetic.

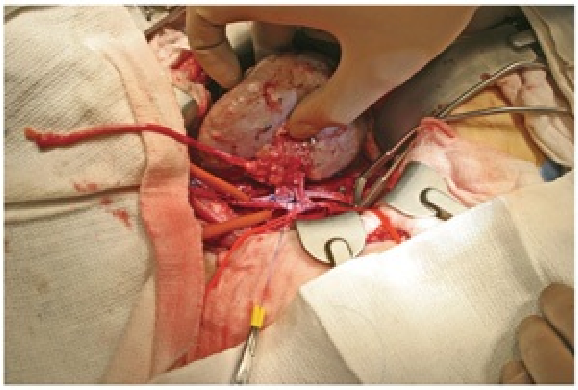

FIGURE 13.17 Revascularized adult kidney transplant in small child; viewed from the patient's left. The renal vein has been anastomosed to the IVC, and the renal artery to the distal aorta. Red vessel loops are around the common iliac arteries and the inferior mesenteric artery. Horizontally oriented vascular clamps are on the mid-aorta and IVC.

Do the ureteroneocystostomy with or without a stent. Place a soft suction drain and bring it out through a stab wound. Close the deep wound, usually with running sutures as described for the adult procedure, and close Scarpa fascia and the skin with fine, absorbable sutures. Some surgeons leave a window in the peritoneum to prevent the accumulation of perinephric lymph. If there is immediate function of the kidney transplant, many surgeons will remove the patient’s peritoneal dialysis catheter. An exception is for very small children in a transplant program with an aggressive fluid management protocol. The “third spacing” may result in significant ascites and respiratory compromise. Intermittent drainage of the ascites via the chronic peritoneal dialysis catheter can prevent the need for intubation and mechanically assisted respiration. The management of the tubes and drains is the same as for the adult recipient.

COMPLICATIONS

Table 13.3 describes how to deal with surgical problems that occur shortly after transplantation.

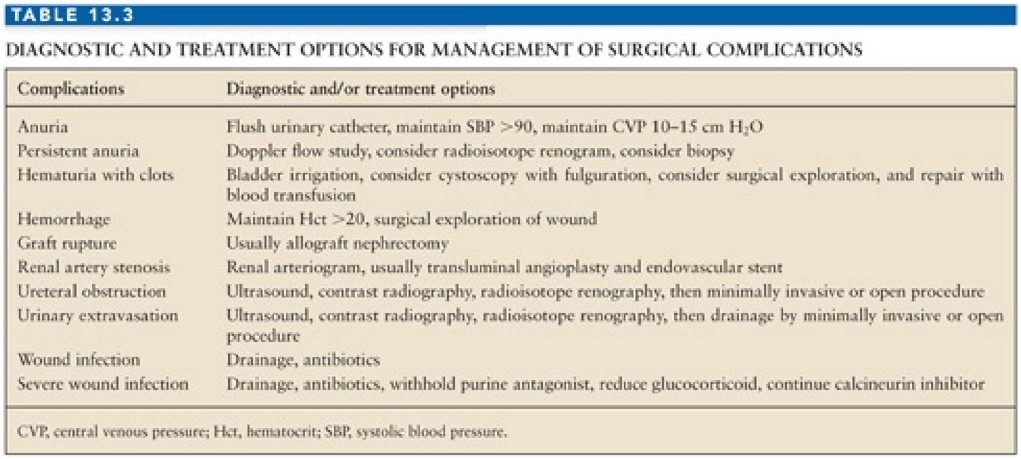

TABLE 13.3

DIAGNOSTIC AND TREATMENT OPTIONS FOR MANAGEMENT OF SURGICAL COMPLICATIONS

Complications	Diagnostic and/or treatment options
Anuria	Flush urinary catheter, maintain SBP >90, maintain CVP 10–15 cm H_2O
Persistent anuria	Doppler flow study, consider radioisotope renogram, consider biopsy
Hematuria with clots	Bladder irrigation, consider cystoscopy with fulguration, consider surgical exploration, and repair with blood transfusion
Hemorrhage	Maintain Hct >20, surgical exploration of wound
Graft rupture	Usually allograft nephrectomy
Renal artery stenosis	Renal arteriogram, usually transluminal angioplasty and endovascular stent
Ureteral obstruction	Ultrasound, contrast radiography, radioisotope renography, then minimally invasive or open procedure
Urinary extravasation	Ultrasound, contrast radiography, radioisotope renography, then drainage by minimally invasive or open procedure
Wound infection	Drainage, antibiotics
Severe wound infection	Drainage, antibiotics, withhold purine antagonist, reduce glucocorticoid, continue calcineurin inhibitor

CVP, central venous pressure; Hct, hematocrit; SBP, systolic blood pressure.

Later, when a kidney transplant recipient has a genitourinary problem, determine what diagnostic and treatment plan would be appropriate if the patient did not have the transplant and then modify it based on the location of the kidney transplant, immunosuppression, and an assessment about whether the proposed treatment plan would make the patient's remaining lifetime better or longer.

OUTCOMES

Ten-year graft survival after living donor kidney transplantation is 60%, and that after deceased donor kidney transplantation is 46% (10). The differences are due to histocompatibility between donor and recipient and kidney quality.

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CHAPTER 14 URETERIC COMPLICATIONS FOLLOWING KIDNEY TRANSPLANTATION

H. ALBIN GRITSCH AND ERIC G. TREAT

Contemporary surgical techniques and improved medical management decreased ureteric complications following kidney transplantation from historical incidence rates of 12% to more conservative modern estimates around 5% (1–4). Albeit different centers and varying practices lead to fluctuating incidence rates seen in the literature, in today's clinical realm, ureteric complications still persist. Many of these complications if promptly diagnosed and managed can be resolved with minimal impact to the patient's long term outcome; however, sometimes they lead to significant morbidity, potential decrease in graft function and survival, and rarely mortality. In recent years, development of less invasive techniques and management strategies fortunately diminished the need for open surgical intervention; however, some cases are best managed with open operative repair.

DIAGNOSIS

In general, ureteric complications following transplantation present as ureteral obstruction, urinary leaks/fistulae, or ureteral reflux; however, the underlying etiologies and time of presentation vary greatly (Table 14.1). Timely identifying the cause of the complication will lead to successful treatment in most cases.

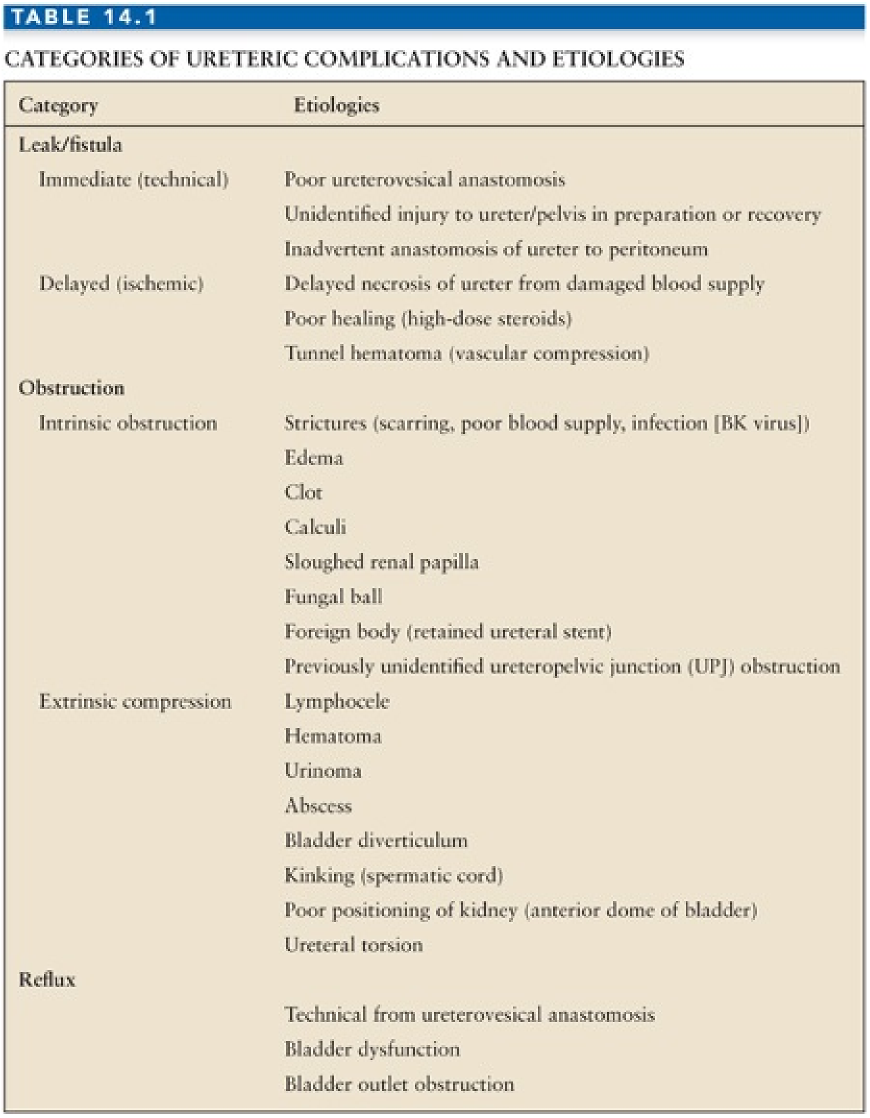

TABLE 14.1

CATEGORIES OF URETERIC COMPLICATIONS AND ETIOLOGIES

Category	Etiologies
Leak/fistula	
Immediate (technical)	Poor ureterovesical anastomosis
	Unidentified injury to ureter/pelvis in preparation or recovery
	Inadvertent anastomosis of ureter to peritoneum
Delayed (ischemic)	Delayed necrosis of ureter from damaged blood supply
	Poor healing (high-dose steroids)
	Tunnel hematoma (vascular compression)
Obstruction	
Intrinsic obstruction	Strictures (scarring, poor blood supply, infection [BK virus])
	Edema
	Clot
	Calculi
	Sloughed renal papilla
	Fungal ball
	Foreign body (retained ureteral stent)
	Previously unidentified ureteropelvic junction (UPJ) obstruction
Extrinsic compression	Lymphocele
	Hematoma
	Urinoma
	Abscess
	Bladder diverticulum
	Kinking (spermatic cord)
	Poor positioning of kidney (anterior dome of bladder)
	Ureteral torsion
Reflux	
	Technical from ureterovesical anastomosis
	Bladder dysfunction
	Bladder outlet obstruction

Ureteral Leak/Fistula

Urinary leaks generally present early after transplantation however can present after removal of a ureteral stent or later occasionally. Leaks are the most common ureteral complication occurring in up to 1% to 5% of transplants (4,5). Presenting signs and symptoms include urine leaking from wound, increased surgical drain output (fluid creatinine levels twofold serum creatinine levels indicates urine), decreased urine output (in patients anuric prior to transplantation), pelvic fluid collections, pain, or unexplained graft dysfunction. Suspicion of a urinary leak should be promptly evaluated. If the diagnosis is obvious, then further testing may be unnecessary. Imaging studies such as abdominal/transplant renal ultrasound or nuclear renogram may aid in the diagnosis. A renal scan demonstrating extravasation is the most sensitive imaging to differentiate a urine leak from other fluid collections such as lymphoceles or hematomas. Differentiating fluid collections as a urine leak from a lymphocele or hematoma is critical because their management is very different. Occasionally, fine needle aspiration and laboratory analysis of a fluid sample may be needed to confirm a urine leak. Voiding cystourethrogram or cystogram may help delineate bladder leaks however are limited in demonstrating leaks at the ureteroneocystostomy site where urine leaks most commonly occur following transplantation. Proximal leaks occur in the ureteropelvicalyceal system when there is concurrent obstruction or infarction. Leakage may also result from injury during recovery, transplantation, or renal biopsy. Bladder leaks are rare because contemporary surgical techniques almost exclusively perform extravesical ureteroneocystostomies. Of note, if a urine leak is detected in the first 4 days following transplant, the cause is most likely technical with the reimplantation. If a leak develops 5 to 10 days posttransplant, the cause is often necrosis from poor ureteral blood supply.

Ureteral Obstruction

Ureteral obstruction typically presents as graft dysfunction. This ureteral complication occurs in 1% to 3% of all transplants (4,5). Patients might develop signs and symptoms around the time of surgery or many years after transplantation. The onset can be sudden or gradual depending on the underlying etiologies (Table 1). Commonly, the onset is gradual and asymptomatic with steadily increasing serum creatinine levels prompting an ultrasound or computerized tomography scan demonstrating hydronephrosis. Pain is rare unless the obstruction is sudden. Again, prompt diagnosis is mandatory in order to undertake the appropriate management. Urinary retention and ureteral reflux must be excluded. A full bladder encountered on examination or imaging warrants decompression with a Foley catheter and careful assessment of postvoiding residuals and serum creatinine monitoring to exclude urinary retention. In some cases of ureteral obstruction, hydronephrosis is minimal. A diuretic nuclear renogram may be useful to reveal ureteral obstruction. When hydronephrosis is present, we prefer to proceed directly to immediate placement of a nephrostomy tube if obstruction is diagnosed. This provides the most definitive diagnosis and allows for relief of the obstruction in a timely manner. Antegrade nephrostogram can more accurately determine the location of obstruction.

Ureteral Reflux

Vesicoureteral reflux (VUR) of urine is common and seen in up to 79% of transplanted kidneys (6). Development of febrile urinary tract illness by reflux of infected urine into the allograft kidney eventually leads to scarring and potential graft loss particularly in pediatric patients (7,8). VUR can be clinically silent; however, worrisome presentation would be in the setting of allograft pyelonephritis (fever, chills, graft tenderness with or without dysfunction along with pyuria, and positive urine cultures). Diagnosis of VUR usually depends on identifying reflux on voiding cystourethrogram. In particular, underlying bladder and voiding dysfunction should be carefully evaluated and addressed. Treatment of any infection should be completed prior to any surgical reconstruction of the refluxing ureter.

INDICATIONS FOR SURGERY

The primary indication for operative management is renal allograft dysfunction caused by underlying anatomic pathology (obstruction, leak, reflux) amendable to surgical correction. Rejection, infection, or other nonanatomic causes of allograft dysfunction need to be carefully excluded and treated prior to definitive operative management of an identified physical abnormality. Rapid placement of a percutaneous nephrostomy tube is indicated to relieve obstruction until more definitive treatment can be undertaken.

ALTERNATIVE THERAPY

Recent technologic advances and improved endourologic techniques make allowance for less invasive approaches to ureteral complications (9). Placement of percutaneous nephrostomy tubes allows for quick diagnosis and temporary treatment of ureteral obstruction or diversion of a significant urinary leak. Maximal diversion with nephrostomy drainage, ureteral stenting, and Foley catheter drainage reportedly resolves urinary leaks in up to 63% of cases (10). For ureteral obstruction from strictures antegrade or retrograde balloon dilation or incision may resolve the blockage. Incisional techniques (even after failed balloon dilation) have reported greater success rates, up to 79% (10). Long-term success when strictures are longer than 1 cm is unlikely. In rare circumstances, prolonged or permanent ureteral stenting or nephrostomy drainage may suffice if open operative repair is inappropriate or contraindicated. For ureteral reflux, endoscopic injection of biomaterial (copolymer of dextranomer and hyaluronic acid) or Deflux (Salix Pharmceuticals, Inc. Raleigh, NC) has shown durable successful outcomes (11). Endourologic interventions prove most successful in carefully selected patients; however, open surgical interventions may be required for definitive treatment.

SURGICAL TECHNIQUE

General Considerations

A variety of surgical procedures exist to address complications of ureteral obstruction, leak, or reflux after kidney transplantation. The choice of which procedure to use depends on the nature of the complication and presentation. In our experience, for distal ureteral obstruction, caused by stricture or tight ureterovesical anastomosis, ureterovesical reanastomosis or “redo” commonly suffices to restore normal continuity of the urinary system. Alternatives include end-to-side or end-to-end ipsilateral native to allograft ureteroureterostomy, ureteropyelostomy, and vesicopyelostomy. These may be necessary if a long stricture or poor ureteral blood supply is encountered. With careful preoperative imaging and planning, the required technique can be anticipated; however, intraoperative findings may call for an alternative approach. Adjunct procedures such as mobilization of the bladder, psoas hitch, or Boari flap techniques may also aid in making a tension-free anastomosis. In our experience, for distal ureteral leaks and fistula, the majority of which emanate from the ureterovesical anastomosis, ureterovesical reanastomosis typically suffices to resolve the leak. For ureteral reflux, a redo anastomosis with attention to a nonrefluxing reimplant resolves most reflux. Again, the aforementioned alternative approaches may aid to create the optimal repair requiring intraoperative flexibility. In general, a well-vascularized, tension-free anastomosis must be created to avoid potential further complications or failure of the repair. A description of all the aforementioned techniques is beyond the scope of this chapter and can be found in other sections of the book, so herein, the redo ureterovesical reanastomosis and ipsilateral ureteroureterostomy will be described in detail.

The patient’s medical and urologic history, previous operations, and anatomy need to be clearly understood with particular attention to bladder capacity, compliance, function, or presence of any voiding dysfunction. Furthermore, native kidney or ureteral pathology needs to be considered especially if use of the native ureter is anticipated. Review all available imaging prior to the procedure, and sometimes an operative imaging study, such as a cystogram or retrograde pyelogram, or rarely cystoscopy with or without ureteroscopy may be warranted. A thorough knowledge of the prior transplant surgery and operative techniques will aid in the surgical repair. Consider the laterality of the allograft (right versus left) and positioning in the recipients pelvis, whether or not the renal pelvis lies anterior or posterior to the renal vessels. Understand the type of vascular anastomosis such as end-to-side or end-to-end and to which target vessels; common, external, or internal iliac; occasionally aorta; or vena cava and whether or not patch grafts, donor vena cava, or other vascular reconstructions were employed. Importantly, knowledge of the type of ureterovesical anastomosis used, such as extra- or intravesical, Lich-Gregoir, or Politano-Leadbetter, will also facilitate and guide dissection and repair and maximize the likelihood of a successful outcome. Prior to operating, assessment of graft function and treatment of rejection or infection need to be stabilized before undertaking operative repair.

Patient Preparation and Exposure

After obtaining surgical consent, the patient is brought back to the operating suite, placed in a supine position on the operating table, given preoperative antibiotic prophylaxis, and has sequential compression devices placed on the lower extremities to prevent deep vein thrombosis. Blood for transfusion should be available. General anesthesia is administered. A urethral catheter is placed. For adults, usually a 16Fr latex catheter suffices. We place a Y connector to the catheter and use a bacitracin saline irrigation solution hanging from an intravenous pole and clamp the urinary drainage bag tube to allow the bladder to fill with gravity. After about 150 mL (approximating the bladder capacity) of irrigation into the bladder, we clamp the irrigation tubing and allow the solution to sit in the bladder for a few minutes. Then by releasing the clamps on the drainage bag, the bladder empties. We keep this setup to allow us to fill or drain the bladder during the procedure when needed. An alternative would be to place the urethral catheter once the sterile field is established and manually irrigate during the case or place a three-way catheter with a similar irrigation setup. The lower abdomen and pubic hair is removed with clippers, and the patient is then prepped and draped.

The prior transplant incision typically suffices to gain surgical access to the transplanted kidney, ureter, and native bladder. If access to the contralateral ureter or extensive mobilization and dissection is anticipated, a midline incision is another option. If a prior midline incision was used (e.g., a kidney-pancreas transplant, or pediatric transplant), the prior midline incision can be used in most cases; however, a new ipsilateral Gibson incision could alternatively be used. Expect a dense fibrosis and inflammatory response 3 weeks after the initial transplant operation. This can last for months. The desmoplastic reaction can make the dissection quite difficult, and if possible, reoperation should be pursued sooner rather than delayed to avoid this inflamed, dense, and tricky dissection. Reoperation soon (within a few days) after the initial transplant requires little redissection in order to establish exposure.

Once the skin is incised, the subcutaneous fat and fascial layers are opened. Generally, through a Gibson incision, the external and internal oblique fascia are divided in an oblique fashion moving laterally from caudal to cranial. If recently transplanted, simply removing the closing sutures suffices to reopen the fascial layers. The allograft kidney lies directly posterior to the fascial layer. The rectus muscle is retracted medially and left intact. Identify the spermatic cord or round ligament and inferior epigastric vessels (often divided in the initial transplant procedure). The peritoneum rests medial to the allograft and should be carefully swept away medial and cranially. We routinely place a Bookwalter retractor to aid in maintaining exposure. Sometimes, a self-retaining retractor or Weitlaner retractor will work. In many cases where only a reimplantation is anticipated and the allograft has been functioning well, we avoid mobilizing the graft and only focus on exposing the ureter and bladder. Minimizing dissection helps prevent unnecessary injury or tissue manipulation. If a hematoma is located lateral to the bladder, the clots should be carefully swept toward the bladder to avoid injury to the ureterovesical anastomosis. However, if needed, the iliac vessels and allograft can be completely mobilized and freed. Figure 14.1 illustrates a left renal allograft placed in the right iliac fossa and the relationship of the recipient's iliac vessels, ureter, and the allograft vessels and ureter.

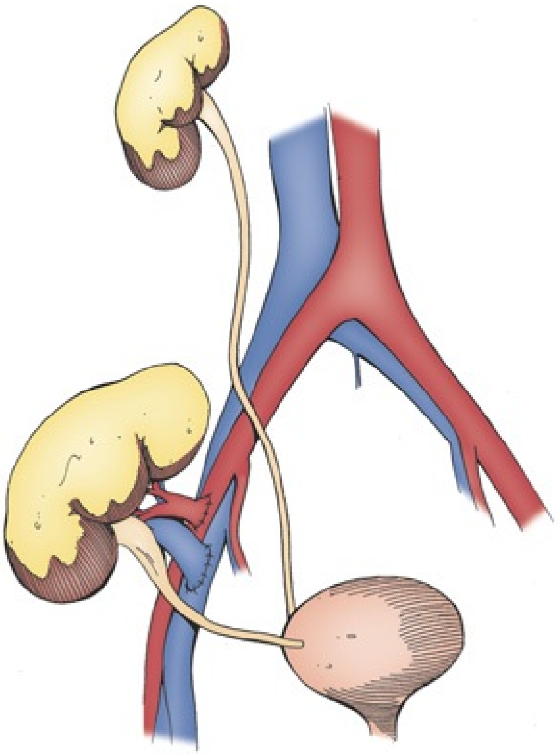

FIGURE 14.1 Relationship of the transplanted kidney and its vasculature to the recipient's iliac vessels and ureter.

Ureterovesical Reanastomosis (Redo) Procedure

Using the pubic symphysis as a bony landmark, the anterior bladder can be identified. Filling the bladder with irrigation solution can help delineate surrounding anatomic structures, and if there is a leak at the original ureterovesical anastomosis, the irrigation can demonstrate the leak and focus the surgical dissection. Adding an ampule of indigo carmine to the irrigation is sometimes helpful to distinguish the leak from either lymphatic or peritoneal fluid. If the complication being addressed is a stricture or ureteral reflux leaking irrigation will not be seen, however, distension of the bladder helps to show where the transplant ureter enters the bladder. Usually, the transplant ureter is found on the anterolateral aspect of the bladder. We prefer to locate the ureter near the bladder rather than the allograft. Because the transplant ureter usually crosses the external iliac vessels below the renal vessels, one should take care to avoid these structures when identifying the ureter. Exact visualization of the renal or iliac vessels is difficult, and many times, one is dissecting based on the expected, not visualized, location of these structures. A Doppler probe and placing a stent within the transplant ureter can facilitate the dissection. Once the ureter is identified, it is carefully dissected free and mobilized proximally with great care to not disturb the blood supply. The ureter should be disconnected from the bladder with effort to maintain as much viable, healthy ureteral length as possible. Sharp transection near the prior anastomosis is preferred. Vascular sutures and clamps should be readily available. A small vascular injury can usually be closed with a simple nonabsorbable monofilament suture. Closure of the distal stump or defect is sometimes not necessary; however, if needed, preferably an absorbable, monofilament suture, 4-0 or 5-0 polydioxanone (PDS, Ethicon, Somerville, New Jersey) may be placed in the detrusor muscle and perivesical fat to seal the bladder leak. The proximal allograft ureter should be inspected for viable tissue. If urothelial mucosal bleeding is observed, this usually indicates viable tissue. If uncertain, a Wood's lamp along with administering an ampule of fluorescein may be used to inspect the tissue for a healthy blood supply.

With the bladder slightly distended, assessment of a new ureterovesical anastomotic site can be made, usually more superior and slightly medial from the prior site with little to no tension. If there is not enough length of the allograft ureter to provide a tension-free anastomosis, several options may provide an adequate solution. Often, mobilization of the bladder on the contralateral side aids enough to allow a reanastomosis. Addition of a psoas hitch can help stabilize the reanastomosis. This might require more mobilization of the allograft to ensure exposure for good psoas fascial suture placement. We prefer two figure-of-eight sutures with 2-0 PDS for the psoas hitch, placed with care in the tendon to avoid entrapment of femoral, ilioinguinal, or genitofemoral nerves coursing along the psoas muscle. Again, use of adjunct procedures or more aggressive techniques (Boari flaps, vesicopyelostomy, bowel interpositions) are seldom needed. End-to-side or end-to-end ipsilateral allograft to native ureteroureterostomy (discussed later), if necessary, can reasonably provide an alternative repair at this point if a tension-free anastomosis cannot be achieved.

Once a location on the bladder is determined and adequate, viable allograft ureter is obtained, we perform a reanastomosis using the Lich-Gregoir technique. With the bladder distended, the perivesical fat is divided by electrocautery in an oblique angle with the proximal aspect being more cranial and lateral. A ratio of 4:1 or 5:1 (tunnel length:ureteral diameter) determines the length of the tunnel, which often amounts to 3 or 4 cm. The detrusor is likewise carefully divided using electrocautery (decreased energy setting to avoid accidental mucosal puncture). The bladder mucosa tends to expand and has a "robin's egg" appearance once the muscle is divided. Detrusor muscle flaps are carefully made, by undermining the detrusor on the lateral aspects of the incision to provide a space for ureteral swelling in the detrusor tunnel upon closure. The allograft ureter is prepared for anastomosis by careful spatulation and placement of a 5-0 PDS from outside to inside (ureteral mucosa) on the most distal apex. A 12-cm 4.5Fr double-J ureteral stent is placed in the ureter. A small mucosal vesicostomy is made using tenotomy scissors at the most caudal and medial aspect of the bladder mucosa. The size of the mucosal puncture should match the spatulated ureter. Having the suction handy aids in removing the irrigation that quickly empties through the mucosal puncture. The ureteral stent is placed inside the bladder and the previous set 5-0 PDS in the ureter is then thrown by starting inside the bladder through the mucosa and small amount of detrusor muscle to bring the apex of the ureter to the apex of the vesicostomy and tunnel and tied. A second 5-0 PDS is placed in the other ureteral apex (crotch) starting outside in and then inside to out on the corresponding bladder mucosa apex and tied. Note this apex does not have any detrusor to anchor the suture. The two apical sutures are used to sew the bladder mucosa to the ureter in a running fashion and loosely tied to each other to complete the anastomosis. At this point, the bladder can be irrigated gently to check for a watertight anastomosis. If satisfactory, then the detrusor tunnel is created. A 5-0 PDS is secured at the caudal-medial end of the tunnel approximating the two detrusor tunnel flaps (created earlier). This is then run the length of the tunnel over the ureter and tied to itself once an adequate tunnel is created. The end of tunnel should be inspected to ensure it is not too tight (leading to obstruction) or too loose (leading to possible bladder diverticulum or reflux). We usually pass a right angle alongside the ureter into the tunnel. It should pass snug but without difficulty. A surgical drain (19Fr round Blake) is placed near but not on the anastomosis and brought out through a separate stab incision and secured with a 2-0 silk drain stitch. We close the fascia in one layer; running 0 PDS from each apex to the middle of the incision and bury the knots. The subcutaneous tissue is closed running a 3-0 polyglactin (Vicryl, Ethicon, Somerville, New Jersey). The skin is closed using a 4-0 absorbable monofilament subcuticular stitch (or staples).

Ipsilateral Native to Allograft Ureteroureterostomy or Ureteropyelostomy

A similar surgical approach as described earlier for ureterovesical reanastomosis is used for identifying the transplant ureter. The incision is extended cranially to identify the native ureter above the allograft in order to avoid the adhesions and difficult dissection planes around the transplanted kidney. An alternative approach is to open the peritoneum to identify the ureter; however, we prefer to avoid entering another anatomic space if possible. Once the native ureter is identified (typically around the crossing of the iliac vessels), careful dissection to mobilize the ureter cranially will allow for a tension-free anastomosis. Great care is given to preserving the periureteral blood supply. Figure 14.2 shows the native ureter mobilized distally and doubly ligated proximally in preparation for ureteropyelostomy.

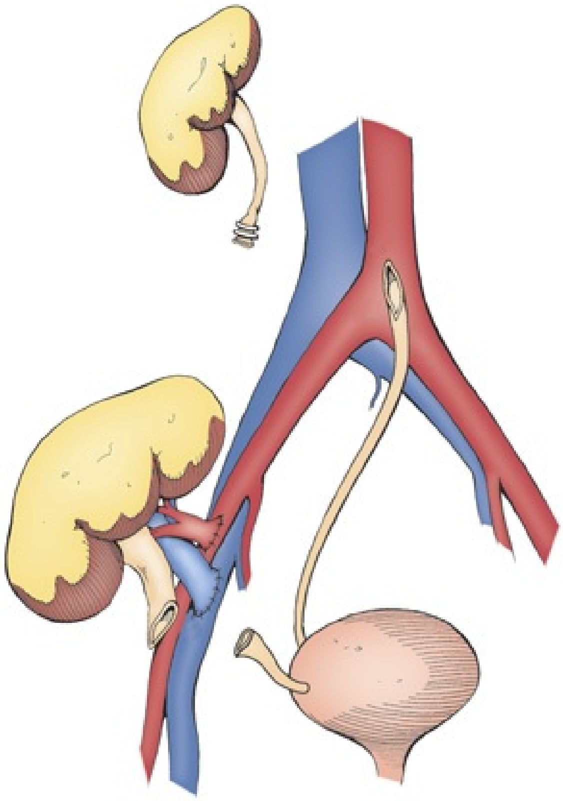

FIGURE 14.2 Mobilization of the native ureter with the proximal segment ligated.

The positioning of the native ureter depends on the relationship to the transplant ureter and/or pelvis. In addition, whether a side-to-side ureteral anastomosis or a ureteropyelostomy is to be performed may make a difference in the exact positioning of the native ureter. All of these factors relate to the extent of fibrosis and the appearance of the transplant ureter. To prevent any additional future problems, a tension-free, widely spatulated anastomosis of well-vascularized ureter to either the transplant ureter or renal pelvis is critical (Fig. 14.3). The anastomosis is performed using 5-0 PDS in a watertight single layer. The critical aspect is to obtain a mucosa-to-mucosa approximation to avoid tension, devascularization, and urinary leak. As shown in the Fig. 14.3 the superior (A’) or inferior (B’) apices can be rotated, and the length of the ureter trimmed to establish an optimal position to avoid kinking of the ureter. A 12-cm 4.7Fr double-J stent is routinely used on all anastomoses. The anastomosis may in addition be wrapped in omentum or peritoneal flap, if available, to decrease further the risk of leak. The wound is well irrigated with antibiotic solution. A closed suction surgical drain is also placed. The closure is the same as described earlier.

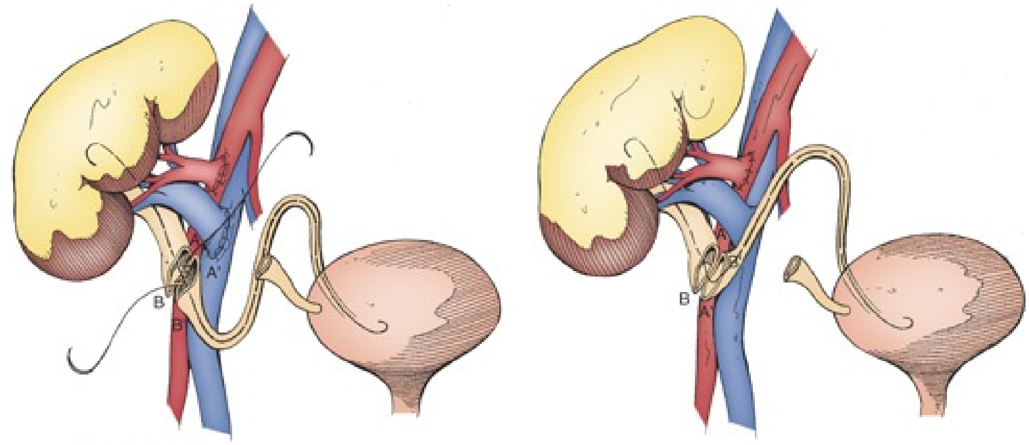

FIGURE 14.3 Anastomosis of spatulated native ureter to (A) transplant ureter and (B) with rotation to prevent kinking.

Typically, for redo operations, a conservative approach is taken with drainage. The Foley catheter is left in place for 3 to 10 days, depending on the extent of repair and condition of the bladder/anastomosis. We remove the surgical drain only if the output is minimal after removal of the Foley catheter. We leave the ureteral stents in place for 3 to 6 weeks.

OUTCOMES

Complications

Immediate postsurgical complications specific to reimplantation include bleeding, urine leak, ureteral obstruction (rare with stenting), and graft failure or loss. Long-term complications include ureteral stricture and scarring, ureteral reflux, urinary fistula, and graft failure or loss.

Results

Rarely will careful reimplantation lead to further ureteral complications or graft loss. In our experience, most ureteral complications have been managed successfully with reimplantation as described earlier. We prefer to avoid using ureteroureterostomy techniques because they are more likely to develop strictures and lead to failure and need for further intervention. Occasionally, we do perform these procedures as secondary or tertiary repairs. In cases of native to transplant ureteroureterostomy or ureteropyelostomy, we tie off the proximal native ureter. We have rarely needed to perform native nephrectomy or have had patient’s develop significant complications from doing so. Sometimes, we have managed significant leaks or strictures with chronic indwelling ureteral stents (with routine exchange) or nephrostomy tubes with reasonable patient comfort and long-term success. However, infectious complications are common with foreign bodies in the transplant urinary collecting system.

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CHAPTER 15 RENAL AUTOTRANSPLANTATION

VENKATESH KRISHNAMURTHI AND DAVID A. GOLDFARB

Having been first performed by Ullman over 110 years ago, renal autotransplantation is now considered a last resort in the spectrum of surgical treatment for upper urinary tract disorders (1). Renal autotransplantation serves to maintain urinary tract integrity in cases of extensive ureteral tissue loss. This operation is also valuable for any disease where intervention on the kidney would expose it to prolonged warm ischemia resulting in permanent renal damage, such as is the case for complex distal renal arterial disease and large kidney tumors where renal preservation is imperative. The basic techniques have evolved as a consequence of developments in the field of renal allotransplantation, particularly an improved understanding of renal preservation. The advantages of back-table reconstruction include optimal exposure, use of optical magnification (loupes), a bloodless surgical field, and incorporation of renal preservation techniques (intracellular flush solutions and hypothermia) (2).

DIAGNOSIS

Because there are varied indications for renal autotransplantation, the diagnostic evaluation will vary depending on the indication. Proximal ureteral obstruction and extensive ureteral loss are usually documented by contrast-based imaging studies, such as computerized tomography (CT) scan, intravenous urography, retrograde or antegrade ureteropyelography, or a combination of these imaging modalities. Complex renal vascular diseases are typically identified on CT or magnetic resonance (MR) angiography. Due to the distal nature of renal vascular disease (branch disease) amenable to autotransplant, almost all candidates also have catheter-based arteriographic studies. Renal tumors are assessed by CT or MR imaging. Extensive investigation is typical for the loin-pain hematuria syndrome. Patients have usually had the full spectrum of radiographic testing to assess the renal vasculature, parenchyma, and collecting system. They have also had diagnostic ureteroscopy. Most have had visceral pain blocks that have failed to provide durable pain relief.

INDICATIONS FOR SURGERY

Autotransplantation of the kidney is an acceptable treatment option for patients with impassable proximal ureteral obstruction and extensive ureteral loss (3). Complex renal vascular lesions requiring ex vivo repair can also be successfully managed with renal autotransplantation (2). Lastly, complex intrarenal or central renal tumors may be successfully treated with ex vivo resection and autotransplantation.

Urinary tract disorders that necessitate consideration for autotransplantation include proximal ureteral obstruction that cannot be managed with bladder-based methods of repair (Boari flap, with or without psoas hitch). These bladder-based repairs require the presence of a large capacity bladder and, notwithstanding this prerequisite, these repairs can rarely extend beyond the pelvic ureter. Moreover, even if bladder-based flaps can reach beyond the area of obstruction, successful reconstitution of the urinary tract may be compromised by excessive tension at the site of reconstruction.

Common etiologies of proximal ureteral obstruction include multiple failed repairs of ureteropelvic junction (UPJ) obstruction (failed pyeloplasty or endoscopic repair), desmoid tumor (with or without Gardner syndrome) obstructing the proximal ureter, and extensive ureteral stricture. Prior to pursuing autotransplantation, these patients have generally been managed with indwelling ureteral stents and/or percutaneous nephrostomy tubes. They are completely stent-dependent and often have developed recurrent episodes of pyelonephritis.

An uncommon condition that is amenable to autotransplant would be the loin-pain hematuria syndrome (4). This is characterized by flank pain with gross or microscopic hematuria for which exhaustive diagnostic testing has failed to disclose a specific etiology. Aggressive treatment is driven by the chronic pain that accompanies the syndrome.

Finally, some centers have used ex vivo back-table excision, reconstruction, and autotransplantation for large renal cancers that are not felt to be amenable to in situ repair (5,6).

ALTERNATIVE THERAPY

An alternative to renal autotransplantation in patients with proximal ureteral obstruction is ileal ureteral substitution; however, ileal substitution may not be possible in patients with a history of extensive intestinal surgery, such as those patients with the Gardner syndrome who have undergone total proctocolectomy with ileostomy or ileal pouch creation. Additionally, the long-term consequences of intestinal interposition within the urinary tract are not completely known and must be considered when utilized in younger patients. Therefore, for patients in whom an ileal substitution does not seem favorable, autotransplantation may be the only option.

Complex renal vascular disorders are also an indication for renal autotransplantation. These are most often arterial disorders such as stenoses or aneurysms involving the segmental renal arteries and are difficult to treat with in situ methods. As an extension of the techniques routinely applied in renal allotransplantation, the renal hilum can be readily accessed while the kidney is on the “back table.” Revascularization to branch vessels or excision of aneurysms deep in the hilum is much easier on the back table and thus can be accomplished satisfactorily prior to autotransplantation.

TECHNIQUE OF RENAL AUTOTRANSPLANTATION

Surgical Instrumentation

Autotransplantation of the kidney combines the techniques of living donor nephrectomy and standard renal transplantation within the same patient. Successful performance of these operations requires instrumentation to facilitate fine vascular repairs. Although the specific instrumentation is a matter of individual preference, instrumentation for vascular surgical procedures should include (a) noncrushing vascular clamps designed for blood vessel occlusion, (b) forceps with fine tips designed for handling both small suture needles and the walls of small blood vessels in an atraumatic manner, (c) needle holders with fine tips to grasp small needles yet prevent unwanted needle movement, and (d) an assortment of silastic vessel loops and umbilical tapes for atraumatic vessel manipulation.

Given the variety of sizes and shapes of vascular clamps, appropriate selection depends on the size of the vessel to be occluded and the desired direction of vessel wall occlusion (longitudinal, transverse, or oblique). The jaws of vascular clamps should have rows of interdigitating teeth that allow vessel wall apposition without endothelial damage. Vascular clamps should be applied by compressing the jaws only to the point necessary for blood flow cessation. Excessive or forceful application can result in endothelial damage and subsequent vessel dissection.

For small, delicate blood vessels or relatively inaccessible areas, spring-loaded (bulldog) clamps are useful devices for vascular occlusion. Bulldog clamps also come in a variety of sizes, strengths, and shapes. Additionally, plastic varieties with soft padded jaws may be useful for extremely delicate vessels.

Vascular forceps must have tines that are in direct apposition, and the tips should be precise enough to grasp the vascular adventitia as well as a suture needle. Forceps with rows of interdigitating teeth serve to accomplish both of these purposes. Alternatively, forceps designed for stable needle grasp, such as diamond jaw forceps, do not allow for reliable manipulation of tissue.

Vascular needle holders should also have fine tips to stabilize small suture needles. The two common choices in vascular needle holders are a ring-handled needle holder and the spring-loaded type. Needle holder selection is a matter of individual preference; however, spring-loaded needle holders generally enable precise needle placement without large degrees of wrist rotation. Ring-handled needle holders permit a more stable needle grasp and facilitate accurate needle placement in deep structures or through densely-calcified vessels.

As with surgical instruments, the selection of vascular suture is also a matter of individual preference. The caliber of the suture should be as fine enough to minimize bleeding through suture holes but strong enough to avoid suture line disruption. In most cases, suture sizes between 2-0 and 7-0 will be applicable for vascular procedures in the abdomen and pelvis. At the level of the aorta, a 2-0 or 3-0 suture should suffice, and 4-0 is almost always suitable for the inferior vena cava. As one progresses to smaller vessels, including the common and external iliac arteries and veins, a 5-0 and 6-0 suture is suitable. Repair of small vessels, such as segmental renal arteries, may require a 7-0 or 8-0 suture.

Nonabsorbable sutures should be selected for vascular procedures. Although silk suture has favorable handling and tying characteristics, its popularity has waned with the development of synthetic, nonabsorbable sutures such as polypropylene. In comparison to silk, synthetic monofilament sutures are relatively inert in tissue, have a low coefficient of friction and thereby result in less tissue drag, and tend to retain a greater amount of tensile strength over time. Vascular sutures are swaged onto fine, one-half-circle or three-eighths-circle needles. The vascular needle should be large enough to penetrate tissue yet small enough so as not to cause hemorrhage from the needle holes. A common practice in vascular repair is to use a continuous suture with needles swaged onto both ends. This construction allows for greater flexibility in accomplishing the repair (e.g., closure from both directions). In select instances, specifically that of pediatric vascular surgery, absorbable monofilament suture with a long half-life (e.g., polydioxanone suture) can be used to allow anastomotic growth.

As with all operative procedures, an essential requirement for renal autotransplantation is optimal retraction and exposure of the operative field. We prefer to use a self-retaining, ring-based retractor system that is fixed to the table. For flank exposure, the Bookwalter retractor (Codman & Shurtleff, Inc, Raynham, Massachusetts) provides for excellent exposure of the kidney and renal hilum. We have modified the medium-sized Bookwalter oval by creating a modest angle (20 to 30 degrees) along the two ends of the ring. This enables the ring to better “fit” the patient’s flank during the operative procedure. A standard oval ring works very well in the iliac fossa. Lastly, for midline intraperitoneal abdominal incisions, we have utilized both the Bookwalter retractor system and the Thompson retractor (Thompson Surgical Instruments, Inc, Traverse City, Michigan). In our opinion, the Thompson retractor provides better exposure in more obese patients as the side bars of the retractor can be placed further from the incision. One disadvantage of this feature, however, is that the side bars tend to be closer to the operating surgeon and can be difficult to work around.

Renal Autotransplantation: Operative Approaches

The selection of the incision for renal autotransplantation depends on (a) the patient’s prior surgical history and (b) the indication for autotransplantation. When the autotransplant is being performed to treat conditions affecting the proximal ureter (as opposed to the renal vasculature), we favor placing the kidney into the contralateral iliac fossa. This enables the renal pelvis and ureter to be the most superficial structures such that if repeat procedures are required on the urinary tract, these structures can be accessed without dissecting or retracting the main renal vessels. Although the kidney can be removed and placed in either iliac fossa through a midline intraperitoneal incision, we often prefer a retroperitoneal flank approach for “donor nephrectomy,” when the kidney is being removed for conditions affecting the proximal urinary tract (7). Following completion of the flank approach for the “donor” nephrectomy, the patient is placed back in the supine position, the contralateral iliac fossa is reprepped and draped, and exposure of the iliac vessels is conducted in a standard manner. In theory, combining two separate procedures may result in a longer total operative time; however, this must be balanced against the benefit of extraperitoneal procedures and improved exposure along both the flank and iliac operative fields.

A midline intraperitoneal approach functions very suitably for renal autotransplantation. We prefer to use this technique when the autotransplant is being performed for vascular conditions, since the midline approach enables dissection of any abdominal structure. During repair of vascular disorders, arterial conduits (e.g., hypogastric artery) are often necessary for reconstruction, and these vessels can be easily exposed through a midline intraperitoneal approach. In contrast to two retroperitoneal procedures, the midline approach does require mobilization and retraction of the small bowel and colon, which may add to postoperative ileus. An upper abdominal transverse intraperitoneal approach is not recommended because it is very difficult to expose structures caudal to the aortic bifurcation, such as the iliac vessels.

Lastly, a laparoscopic approach has also been successfully utilized for the donor nephrectomy portion (8,9). In order to effectively utilize the laparoscopic approach, however, the kidney extraction incision should be made over the iliac vessels for subsequent implantation of the autograft. As mentioned previously, when autotransplantation is performed for urinary tract disorders, placement of the kidney in the ipsilateral iliac fossa puts the urinary tract structures in the most posterior location, which is suboptimal should further procedures become necessary.

Technique of Flank Donor Nephrectomy

Following satisfactory induction of general endotracheal anesthesia and placement of the necessary arterial and central venous monitoring lines, a Foley catheter is placed in the bladder. The patient is then placed on his or her side with the kidney that will be operated on facing “up.” The “down” leg is then bent and the “up” leg is maintained in a straight position. Pillows are placed between the legs, and the greater trochanter along the table surface is padded with egg crate mattresses. The kidney rest is maximally elevated and the operating table is placed in a fully flexed position. This enables a maximum distance between the lower ribs and the iliac crest. An axillary roll is placed, and the arms are padded and secured to a double arm board. The patient is then secured to the table prior to preparation and drape of the operative field.

Our preference, in general, is an incision over the course of the 11th rib. Although selection of the 12th rib may be suitable in many instances, the exposure of the kidney through the bed of the 11th rib essentially always provides for adequate exposure of the kidney and renal hilum. The approach through the 11th rib bed has a slightly greater chance of pleural entry, which is easily managed by evacuation of the entrained air or by placement of a thoracostomy tube. The most important aspect of flank donor nephrectomy is exposure of the renal hilum, and the disadvantage of approaching this through the 12th rib is that the hilum may be at the most superior portion of the operative field. Additionally, exposure through the 12th rib bed may require significant caudal retraction on the kidney during mobilization, potentially traumatizing the kidney.

Following incision of the skin, subcutaneous tissue, and superficial flank musculature, the anterior surface of the 11th rib is exposed, and the rib is then dissected in a subperiosteal plane. Once the rib is mobilized to a suitable posterior location, it is transected. It is sometimes necessary to cauterize the cut end of the rib or obtain hemostasis with bone wax. The retroperitoneal space is then entered along the tip of the removed rib, and, once retroperitoneal entry is verified, the abdominal contents are swept off the undersurface of the deeper flank musculature. These muscles are then further opened in the direction of the incision.

The next step in flank exposure of the kidney is diaphragmatic and pleural mobilization. The neurovascular bundle associated with the removed rib is identified, protected and is swept inferiorly and laterally. Care should be taken with the neurovascular bundle in order to avoid denervation injury to the flank musculature. The attachments of the periosteum and diaphragm against the adjacent lower rib are then divided sharply with the electrocautery. We prefer to continue this division all the way back to the insertion of the diaphragm on the psoas muscle, or lumbocostal arch. This allows for excellent exposure, and, by completely mobilizing the pleura and diaphragm, retraction-related tears on the pleura are avoided. Finally, the kidney can be mobilized within Gerota fascia since the procedure is being done for benign conditions. Once the kidney is suitably mobilized, the self-retaining retractor can be positioned to retract all adjacent structures but the kidney.

At the time of kidney mobilization, intravenous mannitol (12.5 g) is given to promote diuresis. A second 12.5-g dose is usually given just prior to renal artery clamping. The perinephric fat is then completely removed. The renal artery and vein are skeletonized to as proximal a level as possible. The renal artery should be dissected so that an adequate length is maintained for the implantation and the diseased portion can be reconstructed; however, it is extremely important not to dissect the artery too close to the aorta, since a minimal amount of artery must be maintained for suitable control. Too short of a stump on the aorta can lead to significant hemorrhagic complications; however, too short of an artery on the kidney can be reconstructed through a variety of techniques. One must differentiate the dissection of the renal artery during an autotransplant from that of in situ revascularization procedures. In revascularization procedures, the aorta is more accessible and may be more readily controlled, in contrast to flank exposures.

On the right side, the renal vein should be dissected all the way to the inferior vena cava (IVC), and the juxtarenal IVC must also be exposed. It is essential to mobilize the IVC posterior to the insertion of the renal vein, as the posterior wall of the IVC must be satisfactorily clamped during extraction of the kidney. On the left side, the adrenal, gonadal, and lumbar venous branches should be divided.

The ureter is dissected typically to the level of its crossing over the iliac vessel. Ureteral length at this level is essentially always suitable when the kidney is implanted in the iliac fossa. In cases of proximal ureteral obstruction, the ureter should be dissected approximately to the level of obstruction, but more importantly, it must be dissected to only a length suitable for reimplantation. A generous amount of periureteral tissue should be maintained with the ureteral dissection. We prefer to include the gonadal vein and intervening tissue along with the ureter. In cases where the ureter is dilated due to chronic obstruction, the need to maintain an adequate amount of periureteral tissue is less important due to the development of neovascularity. The ureter is then divided above the level of the obstruction (if present), and a satisfactory diuresis is verified by observing urine flow from the cut end of the ureter.

The kidney should be palpated to ensure a turgid feel. A soft kidney with no urine production should raise concern for arterial spasm. In these situations, the kidney should not be handled, and warm saline can be placed as an initial maneuver. If the kidney turgor has not improved and the spasm has not abated after a period of several minutes, papaverine can be applied topically along the renal artery adventitia.

When the kidney is firm and there is an adequate diuresis of urine, it is acceptable to proceed with removal. Mannitol (12.5 g) is given intravenously. The renal artery is then clamped and transected and the kidney mobilized so that the renal vein is stretched to maximize length. The renal vein, or IVC, is then clamped, and the vein is divided sharply at a suitable location. The kidney is then passed off to a separate team, who will commence with both surface hypothermia and in situ cold perfusion.

Attention is directed toward securing the renal vessels. The renal vessels can be secured with any combination of ties, clips, or suture ligatures. The renal artery should be controlled in a transfixing manner because non transfixing methods have been associated with hemorrhagic complications. Our practice is to oversew the renal artery stump with a 5-0 polypropylene suture or with a transfixing 3-0 polypropylene suture. The left renal vein can be similarly controlled (Figs. 15.1 and 15.2). On the right side, however, it is essential to remove the kidney with a small (few millimeters) margin of IVC (Figs. 15.3 and 15.4). In this situation, the vena cava is closed with a 4-0 polypropylene suture. We generally place one suture at each apex and run toward the midpoint. It is not essential to run this closure in an over-and-back manner as the low-pressure venous system is unlikely to leak between the suture lines. It is also important to leave a suitable margin of vein above the clamp so the cavotomy can be safely closed. If the renal vein is transected directly on the clamp, either of two approaches can still be employed to ensure a hemostatic closure. One option is to place a larger clamp below the existing clamp and to remove the first clamp. If this option is pursued, it is imperative to make sure that the second clamp is properly placed and that the walls of the vena cava are in proper apposition. Another, potentially safer option is to reapproximate the IVC walls in a horizontal mattress fashion by sewing "under" the clamp. In all cases, we recommend that the vena caval clamp be slowly released so that it can be immediately reapplied should there be unexpected, significant bleeding from the vena caval closure.

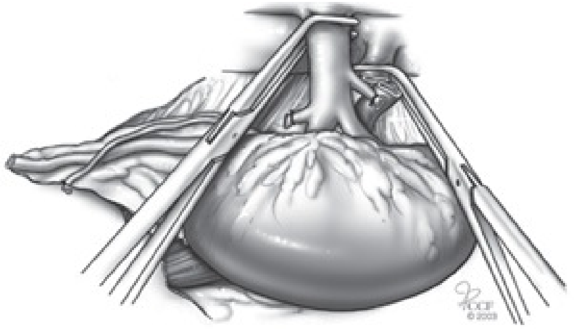

FIGURE 15.1 Control of left renal hilum. Note that the renal vein is clamped as close to the IVC as possible. (Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 2002–2014. All rights reserved.)

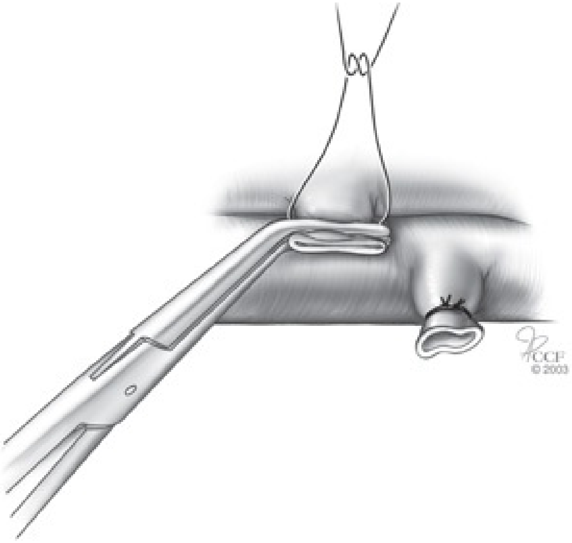

FIGURE 15.2 A small stump of left renal artery is preserved to ensure safe ligation. (Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 2002–2014. All rights reserved.)

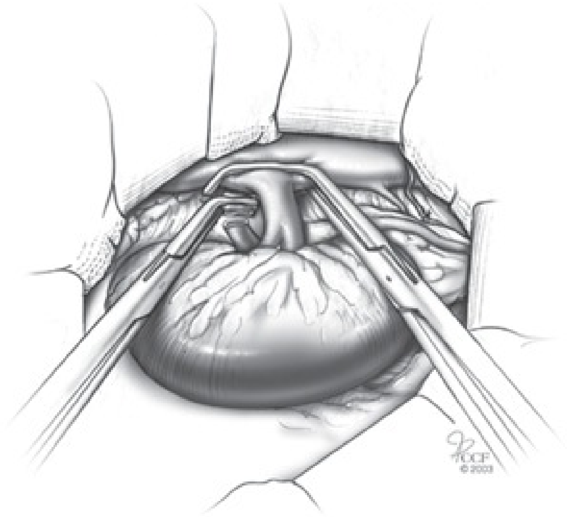

FIGURE 15.3 Control of the renal vein includes a small cuff of IVC. (Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 2002–2014. All rights reserved.)

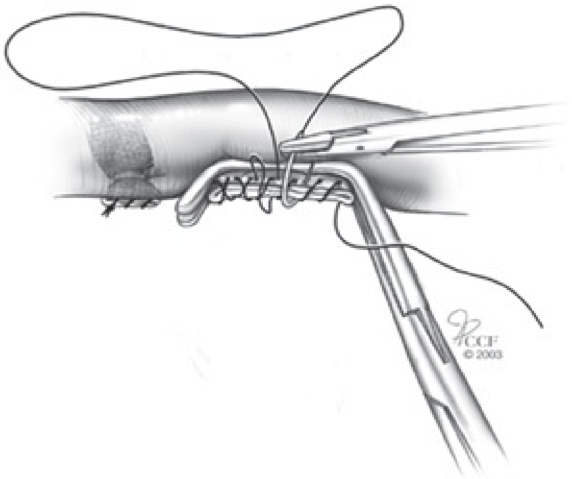

FIGURE 15.4 Securing the IVC with a running suture. (Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 2002–2014. All rights reserved.)

Once the renal vessels are secured, the operative field is irrigated and inspected for hemostasis. The retractor is then removed and the adjacent structures are inspected. If necessary, pleural entry is closed at this time, and the flank musculature and fascia are closed in two layers. Following completion of the flank procedure, general anesthesia is maintained and the patient is repositioned for the renal transplant procedure.

Donor Nephrectomy via a Midline Intraperitoneal Approach

The patient is placed in the supine position with both arms abducted. After satisfactory induction of general endotracheal anesthesia, appropriate arterial and central venous monitoring lines are placed. A Foley catheter is placed in the bladder in a sterile manner. Surgical preparation should include the field from the upper chest to the lower thighs. The genitalia should be shaved and prepped and covered with a sterile surgical towel. Both groins should be available for access should there be a need for saphenous vein procurement.

For renal autotransplantation, a midline incision from xiphoid to pubic symphysis should be employed. After dividing the subcutaneous tissues and linea alba, the abdomen is entered and the abdominal wall can be retracted with a self-retaining retractor. It is important to ensure complete neuromuscular blockade so that the maximal retraction of the abdominal wall can be accomplished. For right-sided autotransplantation, we mobilize the right colon and duodenum medially to expose the entire infrarenal vena cava, left renal vein, and abdominal aorta. For left renal autotransplantation, the left colon should be mobilized medially so that the left renal vein can be accessed as it crosses over the aorta. Following mobilization, the viscera are padded and retracted with the self-retaining retractor. The kidney can be mobilized within Gerota fascia, as mentioned previously. The ureter should be mobilized with a generous amount of periureteral tissue to either the point of obstruction or to a level where it crosses the iliac vessels. When autotransplantation is being performed for vascular conditions, the ureter does not always need to be divided as the renal vascular reconstruction can be performed in a basin containing iced slush placed on the patient’s abdomen. We typically divide the ureter so that the kidney can be taken off the operative field and exposed maximally on the back table, during which time the iliac fossa can be prepared by a separate surgical team.

With the kidney fully mobilized and the ureter divided, the renal vessels are dissected. Because cases of renal autotransplantation for vascular diseases often involve arterial disorders, we feel it is important to completely skeletonize the renal vein so that it can be mobilized away from the posterior renal artery. Accurate preoperative judgment is essential to determine the feasibility of in situ repair. However, even in cases in which in situ repair is thought to be unfeasible, intraoperative findings may dictate otherwise, and the surgeon should be prepared to reconstruct the kidney in situ. However, in cases of proximal ureteral obstruction and in cases of vascular disease requiring ex vivo repair, the kidney has to be removed and reconstructed on the back table. As previously described, the vessels are dissected as proximally as is necessary to correct the lesion. Intravenous mannitol (12.5 g) is administered. After an adequate diuresis and a firm kidney are verified, the renal artery is clamped and divided, the renal vein or IVC is clamped, and the vein is divided. The kidney is passed off to a separate team, who will commence surface hypothermia and in situ cooling. The main renal vessels are secured, and the field is inspected. As the kidney is being perfused, the iliac fossa can be prepared by a separate surgical team.

Back-Table Preparation of the Renal Autograft

Once the kidney is removed, it should be placed in a basin containing ice slush. The renal artery is carefully cannulated and in situ perfusion with cold preservation solution started. Cannulation may be achieved with a large-gauge angiocatheter (14-gauge) or a metal-tipped cannulation device. Arterial cannulation must be performed in a manner that avoids damage to the arterial intima and/or arterial dissection.

Because there is minimal ischemic time during renal autotransplantation, nearly any cold intracellular electrolyte solution can be used to provide in situ cooling for the kidney. In our center, we routinely use a modified Euro-Collins solution. We prefer to perfuse the kidney with an entire volume of perfusate (approximately 1,000 mL); however, it is necessary to perfuse a kidney only until the entire parenchymal surface is blanched and the venous effluent is clear. In cases of multiple arteries, all arterial branches need to be separately perfused as these represent end vessels to the kidney. Very small vessels may require manual perfusion with a syringe and a small-caliber (22-gauge) angiocatheter tip. Once the kidney has been perfused, the renal vasculature can be prepared. The renal vein should be dissected back to its segmental branches. Small venous tributaries are ligated with silk ties and divided. Large segmental branches should be preserved, and it is imperative to maintain at least 50% of the total venous drainage of the kidney. Once the vein is skeletonized back to its segmental branches, it can be retracted away from the artery, which can then be similarly dissected. The lymphatic tissue surrounding the artery is sharply excised and secured along the segmental arterial branches. Large lymphatic trunks in this location should be secured with silk ties in order to prevent a lymph leak, particularly if the implantation of the kidney is going to be placed in a retroperitoneal location. Once the artery has been mobilized to its segmental branches, it should be ready for implantation. Any remaining perinephric fat should be removed, and, if indicated for additional histologic information, a needle biopsy of the kidney is performed at this time.

In cases of renal vascular disease, the renal artery should be dissected distally, beyond the level of the disease. The diseased segment of the artery or arteries should be excised, and the remaining normal artery or branch artery can be reconstructed in a variety of techniques (Fig. 15.5).

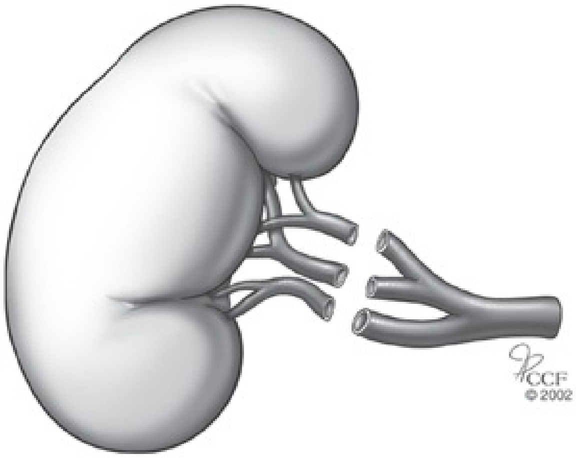

FIGURE 15.5 The native hypogastric artery can often be used as an interposition graft in complex branch renal artery repair. The hypogastric artery must be free of significant vascular disease to be useful. (Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 2002–2014. All rights reserved.)

Implantation of the Renal Autograft

Exposure of the Iliac Vessels

As mentioned previously, the site for renal autograft implantation can be exposed by a second surgical team while the kidney is being prepared on the back table. A standard lower quadrant oblique (Gibson) incision can be used to enter the retroperitoneum when two separate incisions are utilized for autotransplantation. Of particular importance with the retroperitoneal approach, large lymphatic trunks should be ligated prior to division to prevent postoperative lymphocele. We typically expose the full length of the external iliac artery, specifically from the common iliac bifurcation to the inguinal ligament. The external iliac vein is similarly exposed from the inguinal ligament to the first major posterior branch. The external iliac artery is almost always free of branches until the most distal aspect, where the epigastric vessels arise. The external iliac vein can often have posterior tributaries (e.g., obturator vein), and division of these vessels lends significant mobility to the external iliac vein. The internal iliac or hypogastric vein is a large trunk, often composed of three veins, entering along the posterior aspect. Division of this vessel must be approached with care as the hypogastric vein is very short and very wide and loss of control of this vein can lead to significant hemorrhage. We prefer to divide this vein only when the iliac vein needs to be mobilized lateral to the external iliac artery due to a short renal vein. Our approach to dividing the hypogastric vein(s) is to (a) medially mobilize the external, internal, and common iliac arteries and (b) obtain circumferential control of the external iliac vein and common iliac vein (we prefer to encircle these vessels with silastic loops). This approach works well with a short hypogastric vein(s) as it can be difficult to obtain enough distance between two ties. Accordingly, we have found that titanium clips provide satisfactory occlusion along the proximal aspect. If another tie cannot be placed on the distal aspect (insertion into the external iliac vein), this orifice can be suture-ligated after occluding flow in the external and common iliac veins.

In contrast to an extraperitoneal approach, the iliac vessels can be exposed directly when using an intraperitoneal approach. Lymphatic trunks are simply cauterized, and similar exposure of the iliac vessels is obtained. Another advantage of an intraperitoneal approach is that it is often easier to expose larger vessels for implantation, specifically the common iliac artery and infrarenal vena cava. These vessels are more accessible and larger caliber, features that may facilitate renal vascular anastomoses.

Important points in selecting the target for renal autograft implantation are that (a) the vessels should be adequately mobile to allow for tension-free anastomoses to the renal artery and vein and (b) the inflow artery should be sufficiently free of atherosclerotic disease. The second point deserves further elaboration in that, not only should the anastomotic site be acceptable, but the location for clamp placement should also be "soft." If there is concern over the suitability of the artery, a "softer" location should be explored both proximally and distally.

Renal Autograft Revascularization

Revascularization of the kidney is commenced by anastomosis of the renal vein to the iliac vein (or vena cava) (Fig. 15.6). We typically occlude the iliac vein with a tangentially occluding or Satinsky-type clamp. An appropriate-length venotomy is made on the anterior wall, and the lumen is irrigated with heparinized saline. The kidney is brought into the operative field, and a continuous anastomosis is completed by first placing sutures at both apices of the venotomy and then running around each "side." For anastomosis to the iliac vein, both 5-0 and 6-0 polypropylene sutures are acceptable, and when the vena cava is used for outflow, 5-0 polypropylene is suitable.

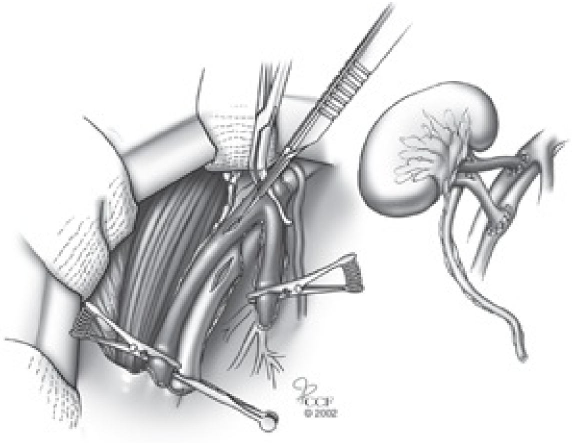

FIGURE 15.6 This figure demonstrates regional control of the external iliac artery and vein. It also shows the final appearance of the transplanted kidney. (Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 2002–2014. All rights reserved.)

In the majority of cases, we perform the arterial anastomosis following completion of the venous anastomosis. The iliac artery (common or external) is occluded with vascular clamps both proximally and distally. Alternatively, a single clamp (Satinsky type) can be used for arterial occlusion as well, but the disadvantage to this approach is that the artery cannot be unclamped without restoring the high-pressure antegrade flow. Following clamp control, the periadventitial tissue at the proposed site of anastomosis is sharply excised, an arteriotomy is made with a no. 11 blade, which is then further fashioned to match the caliber of the renal artery, and the lumen is irrigated with heparinized saline. We commonly use a continuous 6-0 or 7-0 polypropylene suture to complete the end-to-side anastomosis to the iliac artery.

Following completion of the vascular anastomoses, we release the venous clamp first, then the distal arterial clamp, and last the proximal arterial clamp. This allows the anastomoses to be "tested" in a low- to high-pressure direction. Once hemostasis is ensured, the operative field and kidney are bathed in warm saline solution, after which the kidney is inspected for uniform perfusion. The renal cortex may take several minutes to become homogenously perfused (pink-appearing), and soon after this occurs, urine production should be seen from the distal end of the ureter.

Ureteroneocystostomy

In general, we prefer to reimplant the autograft ureter in an extravesical full-thickness manner (Fig. 15.7). We do not feel that creation of an antireflux tunnel is essential and direct anastomosis solely between the ureteral and bladder mucosa may have a higher incidence of anastomotic urinary leaks (10).

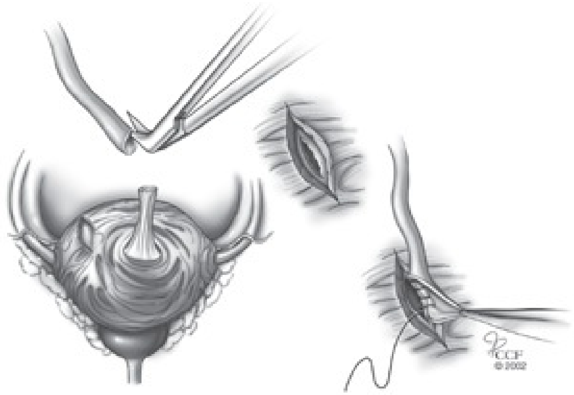

FIGURE 15.7 The location and creation of the extravesical ureteroneocystostomy is demonstrated. (Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 2002–2014. All rights reserved.)

Unlike dialysis-dependent patients who are undergoing renal allotransplantation, nearly all patients who are undergoing autotransplantation have “normal” urine volumes and “normal” bladder capacities. The bladder, which is readily distensible in autotransplant patients, is filled by instillation of saline solution, and the perivesical fat over the intended site of ureteral reimplantation is removed with electrocautery dissection. Occasionally, large veins in the perivesical fat must be ligated, and in these instances, absorbable suture should be used to avoid potential migration into the anastomosis.

We then trim and spatulate the ureter at an appropriate length. For renal autotransplantation, the ureter is not excessively long and does not need to be trimmed to any significant degree (1 to 2 cm at most). Additionally, unlike the ureter received with a deceased donor renal allograft, the viability of the autograft ureter can be ensured during the nephrectomy. Periureteral vessels are ligated with absorbable ties, and the ureter is spatulated for a distance of approximately 1 cm. The detrusor musculature is then divided with the electrocautery, with care taken to avoid entering the bladder mucosa. The bladder mucosa is entered sharply, and the ureter is anchored at this site with one or two absorbable sutures placed at the “heel” and “toe” of the anastomosis, respectively. We prefer to complete the typical extravesical ureteroneocystostomy with a continuous 5-0 polydioxanone suture. Routine use of an indwelling double-J stent is dependent on surgeon preference; however, if there are concerns over the integrity of the anastomosis or the viability of the ureteral end, use of a stent is recommended.

Alternative urinary tract reconstructive approaches should be considered in cases of renal autotransplantation for urinary tract obstruction and/or intractable stone disease. In these situations, the proximal ureter and renal pelvis are often markedly dilated, and direct anastomosis to the bladder provides unobstructed urine drainage and stone passage. The optimal position for the kidney should be determined prior to revascularization. Following this, urinary tract continuity can be reestablished either directly or through bladder- and/or ureteral-based flaps (11).

Closure of Incision

Prior to closing the incision, we ensure an appropriate position for the kidney. In most cases, the kidney can be placed on the psoas muscle, with the lateral aspect of the kidney directed laterally and the hilum directed medially. This position places the urinary tract in a medial position, should later access be necessary. Once the kidney is positioned, cortical perfusion should be verified and the hilum should be palpated to ensure a strong arterial pulse. Additionally, satisfactory drainage from the renal vein can be ensured by the palpation of a soft, easily compressible renal vein.

We reapproximate the abdominal wall musculature most often in a single layer. We typically close a midline incision with a single layer of no. 1 polydioxanone or no. 1 polypropylene. For most retroperitoneal incisions, one layer is satisfactory. In cases where the abdominal wall is thin and the musculature is attenuated, closure in two layers can provide adequate reapproximation.

OUTCOMES

The end points for outcomes vary according to the indication for the procedure (ureteral obstruction, renal vascular disease, loin-pain hematuria syndrome). Preservation of the affected kidney is very high. Several reports have demonstrated >90% technical success rates for renal autotransplantation that seem durable. Understand that autotransplantation for a diseased kidney is a more complicated endeavor than renal allotransplantation. Simultaneous donor and transplantation procedures are performed on the same individual, which is an enormous physiologic burden. The kidney being autotransplanted is often anatomically compromised. This is in contrast to the donor kidneys in standard allotransplantation, which are normal, and for which the reported technical loss rates are <5%.

COMPLICATIONS

Complications of using autotransplantation may derive from the procurement of the kidney or may be related to the implantation of the kidney. The main complications arising from procurement would be bleeding and injury to adjacent viscera (colon, pancreas, spleen, liver). From the implantation portion of the procedure, there may be vascular problems. The biggest concern is the potential for arterial or venous thrombosis. Attending to proper vascular technique and ensuring appropriate geometric alignment of the kidney in its final location will help prevent vessel kinking. Recipient vessel dissection or embolization is rare; nonetheless, early recognition and repair are required to avoid catastrophic limb-threatening problems. With respect to the ureter, there is potential for urine leak or obstruction. Attention to creating a tension-free anastomosis by using a ureter with a well-preserved blood supply is important. Given the diseased status of the vessels or ureter, a ureteral stent is recommended. Finally, when kidneys are autotransplanted into a retroperitoneal position, lymphocele is possible. Meticulous ligation of perivascular lymphatics will help to prevent this complication. A retroperitoneal drain for a brief period may also help avoid this complication. If a lymphocele is causing graft dysfunction, it can be drained percutaneously or surgically.

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CHAPTER 16 ■ MISCELLANEOUS LAPAROSCOPIC UROLOGIC PROCEDURES: LYMPHOCELES, CALCULUS, VARICOCELE, URETEROLYSIS

SRI SIVALINGAM, SEAN P. HEDICAN, AND STEPHEN Y. NAKADA

The evolution of laparoscopic surgery permits it to be a viable alternative to less commonly used miscellaneous procedures such as lymphocele repair, urinary calculi, ureterolysis, and variocele ligations. Ongoing refinements and advancements continue to evolve with the use of laparoendoscopic single-site surgery (LESS) and robot-assisted approaches for these specialized procedures.

LYMPHOCELE REPAIR

Lymphoceles are localized encapsulated collections of lymphatic fluid created by disruption of lymphatic vessels that can occur following renal transplantation or other procedures during which lymphatic channels are transected in the pelvis or retroperitoneum. The incidence of asymptomatic lymphoceles following renal transplantation or combined kidney pancreas transplantation has been reported to be as high as 20% (1). Contributing factors in transplant patients include episodes of rejection, cytomegalovirus infections, and posttransplantation reoperations (2,3).

Disruption of the lymphatics during pelvic lymphadenectomy for prostate cancer has also led to localized lymphoceles, with a reported incidence of 0.5% to 10% (2,4,5). Significant contributing factors to the formation of the lymphoceles include the administration of low-dose heparin (6), prior radiation, presence of metastases, surgical technique, and the extent of the dissection (5). Fortunately, the majority of these pelvic lymphoceles remain clinically asymptomatic. Lymphoceles have also been described following retroperitoneal procedures including nephrectomies, retroperitoneal lymph node dissections for testis cancer, or aortic surgery.

Diagnosis

Asymptomatic lymphoceles are usually discovered incidentally at the time of renal allograft ultrasound (Fig. 16.1) or computerized tomographic (CT) imaging of the abdomen and pelvis (Fig. 16.2) performed for unrelated indications. They appear as a single or septated chamber with Hounsfield unit characteristics and echotexture consistent with fluid located in the region of the renal allograft or adjacent to the iliac vessels. Lymphoceles related to radical prostatectomy occur primarily in the pelvic cavity, and a recent series that evaluated 105 symptomatic lymphoceles following radical prostatectomy requiring intervention reported that the most characteristic locations are paravesical (69.5%), lateral pelvic wall (16.5%), deep pelvic (6.7%), prevesical (4%), and pelvic with retroperitoneal extension (2%) (7).

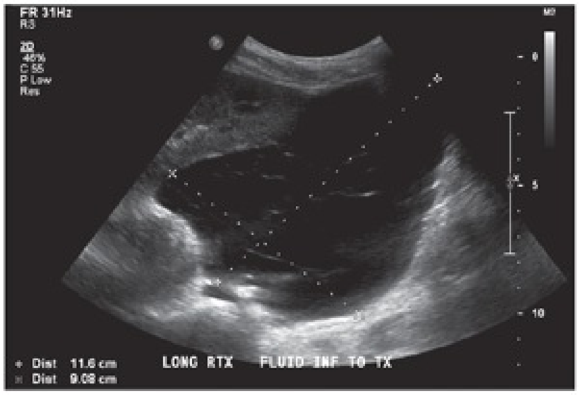

FIGURE 16.1 Ultrasound images of a large lymphocele containing low echogenic fluid extending below and medial to the transplant kidney.

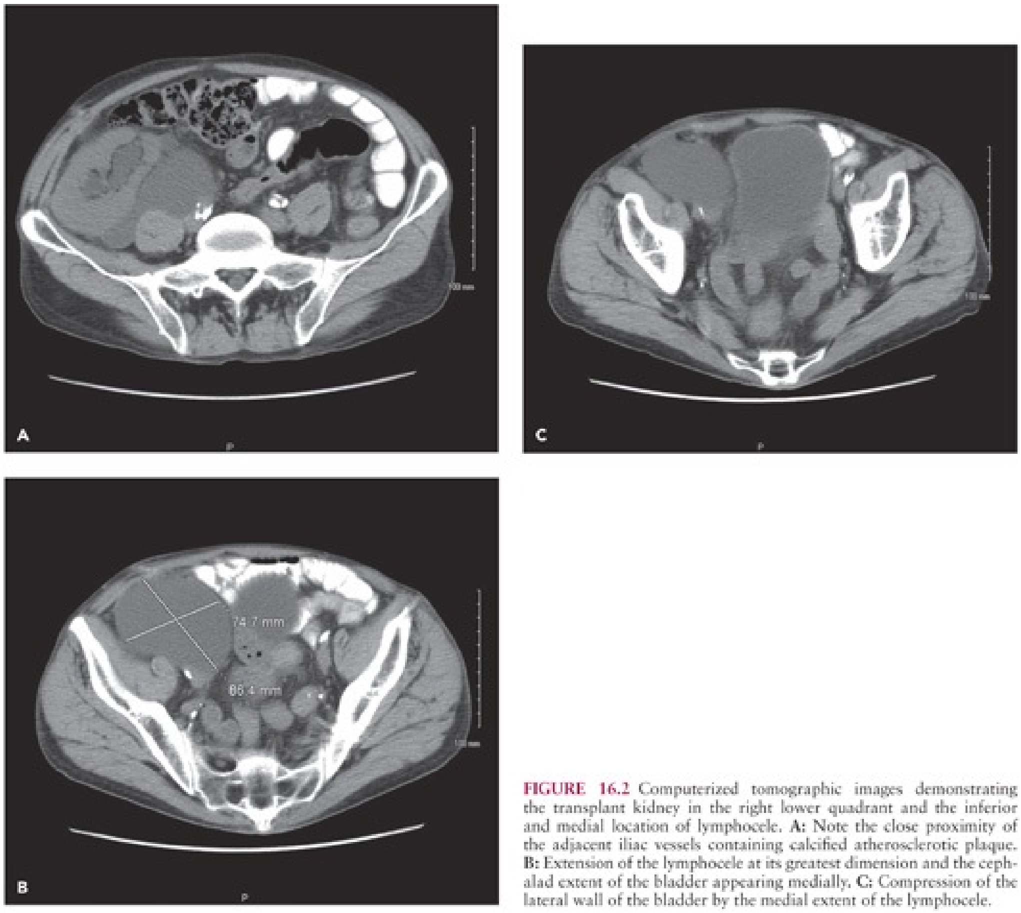

FIGURE 16.2 Computerized tomographic images demonstrating the transplant kidney in the right lower quadrant and the inferior and medial location of lymphocele. **A:** Note the close proximity of the adjacent iliac vessels containing calcified atherosclerotic plaque. **B:** Extension of the lymphocele at its greatest dimension and the cephalad extent of the bladder appearing medially. **C:** Compression of the lateral wall of the bladder by the medial extent of the lymphocele.

Lymphocele collections can be difficult to differentiate from a urinoma unless an ongoing urine leak can be documented via contrast or radionuclide imaging. In the case of a urinoma, aspiration and analysis of the fluid will demonstrate a creatinine value elevated above corresponding serum values

(8). The creatinine value on the fluid aspirated from a lymphocele will be equivalent to serum. Hematomas and abscesses usually contain fluid with a higher echogenicity on ultrasound examination, with an increased nonenhanced density on CT imaging (9). The presence of signs and symptoms of an infection in association with a high-density fluid collection, often with mild enhancement of thickened walls or surrounding tissue stranding, usually denotes an abscess. The diagnosis is confirmed and therapeutic intervention often begins with percutaneous drainage or aspiration of purulent material (2).

Indications for Surgery

The primary indication for a lymphocelectomy (surgical unroofing or marsupialization of a lymphocele) is symptoms related to its mass effect. The reported incidence of symptomatic lymphoceles following renal transplantation ranges from 3% to 7% (10,11). Symptomatic lymphoceles after pelvic lymphadenectomy following radical retropubic prostatectomy are relatively rare, but some series have reported the prevalence of lymphoceles following prostatectomy as high as 10% (12). Fortunately, the majority remains asymptomatic and resolves spontaneously. One study showed that only 2.4% of lymphoceles following radical prostatectomy were symptomatic and 2% required intervention (13). Symptoms necessitating surgical drainage and unroofing include labial, scrotal, or lower extremity swelling; deep venous thrombosis with or without pulmonary embolism; a sensation of pelvic fullness; and irritative voiding complaints due to compressive effects on the bladder or rectum (5). Renal transplant dysfunction secondary to ureteral obstruction with associated hydronephrosis versus direct compressive effects on the allograft has also been reported. A review of indications for surgery in transplant recipients demonstrated that 69% were performed for local symptoms, 14% for graft dysfunction, and 17% for both (10). Ureteral obstruction following pelvic lymphadenectomy for prostate cancer is extremely rare (5).

Alternative Therapy

Prior to the first reported case of laparoscopic lymphocelectomy in 1991 by McCullough et al. (14), the treatment of choice for a symptomatic lymphocele was open transperitoneal marsupialization, with a reported complication rate of 4% and a recurrence rate of 15% on review of 129 patients undergoing open lymphocelectomy (11). This method is still used for complex lymphoceles that are multiseptated and lying in a difficult-to-access posterolateral or inferolateral position relative to the allograft. Lymphoceles located in these locations have also been shown to be associated with a higher incidence of conversion from a laparoscopic to open surgery as a result (15). Infected lymphoceles requiring extensive evacuation and washout of purulent debris, excision of all septations, and drain placement also support the use of an open extraperitoneal approach (2,3).

Similar to symptomatic renal cysts, aspiration of lymph fluid alone via a percutaneous approach is associated with a 75% to 100% incidence of lymphocele recurrence. These results are not significantly improved by insertion of a percutaneous drain. The use of sclerosing agents instilled into the lymphocele cavity has been reported to increase the likelihood of successful ablation to approximately 85% to 90% (3). Sclerosing agents vary depending upon the series, but the use of alcohol, tetra- or doxycycline, povidone-iodine, and fibrin sealant have all been reported (3,16). It should be noted that this treatment usually requires multiple instillations that can last as long as 45 days (3). The use of this approach is contraindicated for complex multiseptated lymphoceles due to incomplete drainage and inability to introduce sclerotic agent into all chambers (16). Sclerotic agents are also best avoided when the ureter contacts one of the walls of the lymphocele due to the concern that the inflammatory response induced could result in periureteral fibrosis and ultimate transplant ureteral obstruction. Infected lymphoceles likewise should not be treated with aspiration and sclerosis even when utilizing antibiotic agents, as this can lead to persistence and even aggravation of the infection.

Surgical Technique

Preoperative Preparation

Patients are placed on a clear liquid diet beginning at noon the day prior to their procedure and are also instructed to drink a bottle of magnesium citrate in an effort to cleanse the bowel. Decompression of the bowel aids in visualization during the operation and improves the speed of bowel recovery. On call to the operating room, the patient is administered a single dose of an appropriate intravenous broad-spectrum antibiotic. Patients on long-term steroid immunosuppressive therapy may require supplemental stress dosing per the anesthesia team. Compressive knee or thigh-high stockings (T.E.D.) and sequential compression devices are applied to the lower extremities to reduce the risk of deep venous thrombosis formation. Hair is removed from the area of the operative field, including the pubic region and lower abdomen, using electric clippers.

Patient Positioning

The operating table should be equipped with a kidney rest and allow flexion/deflection and full Trendelenburg positioning. A 3-inch foam pad mattress is placed on the operating table, followed by a full-size gel pad to aid in securing the patient. Prior to transferring the patient from the transport bed to the operating table, 70% isopropyl alcohol can be used to cleanse the back to remove body oils and debris to establish secure traction between the patient and the gel pad without the use of shoulder bars, chest tape, or straps. Alternatively, any of the other aforementioned securing methods can be utilized. Following intubation of the patient, an orogastric tube is inserted to decompress the stomach, and nitrous oxide should be avoided to prevent bowel distention and to reduce the risk of creating a combustible environment when electrocautery is being utilized. The patient should be positioned with the umbilicus at the region of the kidney rest to allow flexion of the table with slight kidney rest elevation to increase the distance between the umbilicus and the pubic symphysis, assisting in spacing of the trocars.

The Foley catheter should be inserted on the operative field after preparing and draping to allow access for filling and decompressing the bladder, which may assist in localization of the lymphocele. Male patients are placed supine on the operating table. Female patients should be positioned in low lithotomy using Allen stirrups to allow adequate access to the urethral meatus. Alternatively, slight frog-leg positioning can be utilized in nonobese female patients. If the legs are not secured in stirrups, tape can be placed across the upper thighs and a strap across the lower legs to secure them in position.

The arms are protected in eggcrate foam and tucked at the sides. When arm sleds are utilized, care must be taken to avoid disruption of the securing Velcro on their insertion, as this holds the 3-inch foam mattress in place and can lead to its dislodgement and inadvertent patient movement on deep Trendelenburg positioning. Although it is rarely required, the security of the patient’s position should be tested in full Trendelenburg tilt prior to preparation and draping. A wide surgical skin preparation should be performed to include the genitals for sterile Foley catheter insertion and adequate exposure to allow adequate trocar spacing and conversion to an open operation if necessary.

A standard wide-aperture laparoscopic drape can be utilized when patients are not placed in stirrups; otherwise, standard cystoscopy legging and aperture drapes are utilized after four-towel draping of the abdominoperineal region. The aperture can be enlarged to give adequate exposure to the lower abdomen.

Establishing Peritoneal Access and Trocar Configuration

Access to the peritoneum can be obtained utilizing a closed needle (Veress) puncture technique or an open direct vision (i.e., Hasson cannula) method. If the lymphocele is extremely large, extending to or above the level of the umbilicus, this centrally located port can be moved in a cephalad direction to ensure that the port enters approximately a handsbreadth above the upper extent of the lymphocele. Transabdominal ultrasound can be used to assist in port placement or the extent of the lymphocele estimated by counting CT scan slices above and below the umbilicus to predict its location. The underlying soft tissues are bluntly dissected down to fascia using a sharp clamp.

Pneumoperitoneum is established using standard technique. The insufflation pressure set point should be placed at 15 mm Hg, and once this pressure level is obtained, a visual introducing trocar (e.g., Optiview, Ethicon Endo-Surgery, Cincinnati, Ohio) is used to insert a 10/12-mm port via the previously made periumbilical incision. The 0-degree 10-mm laparoscope is inserted into the Optiview and can be used to visualize each layer of the abdominal wall as it is traversed using a back-and-forth twisting motion until full entry into the peritoneal cavity is confirmed. Once the visual introducing port has been inserted, the 0-degree lens is exchanged for a 30-degree lens to allow a greater range of visualization angles.

Two additional working ports are then placed, adjusting their position depending on the location of the lymphocele. In general, a 5-mm working port is inserted a handsbreadth down from the supraumbilical port just lateral to the midline on the side contralateral to the lymphocele. If the distance between the umbilicus and the pubic symphysis is sufficient to allow placement of two ports separated by a handsbreadth without entry into the bladder, the third port (5 mm) can be placed below the second port in the midline. This also requires that the lymphocele is not exceptionally large and that the patient is not morbidly obese (body mass index <35). In general, placement of this port a handsbreadth lateral to the midline just below the level of the umbilicus on the side ipsilateral to the lymphocele is preferred. In the standard trocar arrangement, a 10-mm port can be utilized to allow lateral camera positioning if desired during the case (Fig. 16.3). Alternatively, a 5-mm port can be utilized if a 5-mm laparoscope is available.

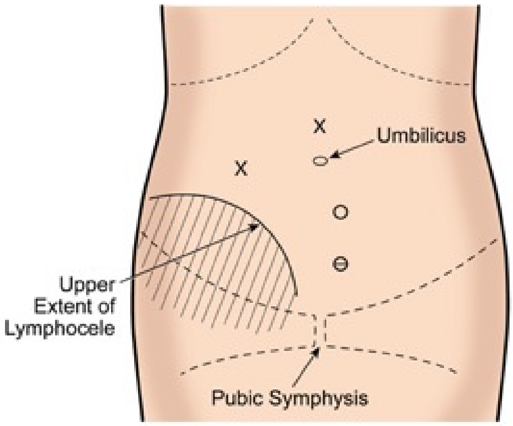

FIGURE 16.3 Recommended port configuration for right laparoscopic lymphocelectomy. X, 10/12-mm port; O, 5-mm port; Θ, alternative 5-mm port.

The surgeon stands on the side opposite the lymphocele and the assistant and scrub personnel stand on the ipsilateral side across from the primary surgeon. The monitor and tower or boom arm containing the insufflation unit, light, and camera source are positioned at the foot of the patient. The patient is placed in Trendelenburg positioning to the extent necessary to liberate the bowel off the area of dissection, and the table is airplaned slightly toward the operating surgeon.

Identification of the Lymphocele

After release of any overlying bowel or omental adhesions to the lower quadrant of interest, the lymphocele can be identified as a bluish-black pelvic structure if thin-walled. The overall appearance can vary significantly, and when the wall is thickened, differentiation from the bladder can be difficult (Fig. 16.4A). Depending upon its location, other surrounding vital structures, such as the transplant or native ureter or iliac vessels, can also be incorporated into one or more of the walls of the lymphocele. Methods to assist in identification and differentiation from the bladder have been described, including distention followed by decompression of the bladder with sterile saline. The bladder can also be filled with indigo carmine or methylene blue–stained saline and a laparoscopic aspirating needle can be inserted into the identified structure presumed to be the lymphocele (Fig. 16.4B). This is confirmed to be the lymphocele if the aspirated fluid does not contain blue-tinged fluid (17).

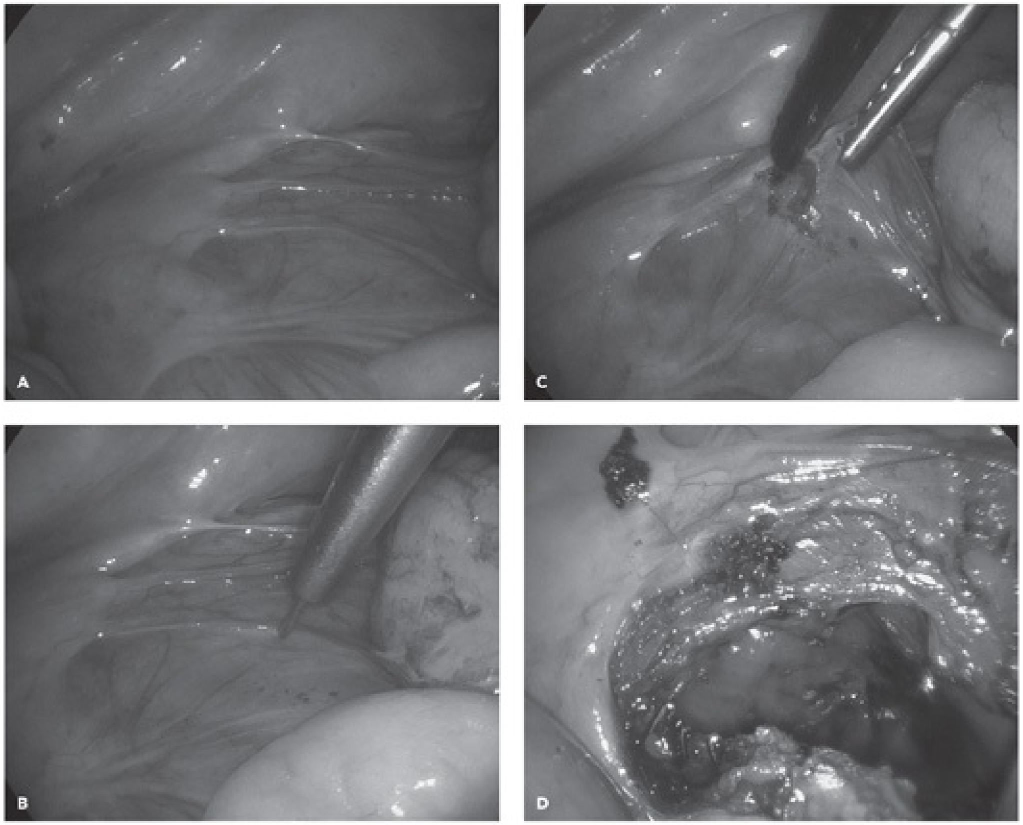

FIGURE 16.4 Laparoscopic view of right lower quadrant lymphocele adjacent to a renal transplant. **A:** Thick-walled appearance making differentiation between the indigo carmine–containing bladder and lymphocele difficult. **B:** Laparoscopic aspiration needle inserted into the lymphocele, yielding clear fluid. **C:** Lymphocele unroofing begins utilizing an electrocautery hook. **D:** Final appearance of wide-mouthed peritoneal aperture created in the lymphocele.

Alternatively, outlining the lymphocele using transabdominal ultrasound and percutaneous needle puncture with aspiration followed by injection of the lymphocele with dilute methylene blue–tinged saline results in staining of the walls of the lymphocele, allowing confirmation of the structure prior to unroofing by laparoscopic needle aspiration with return of blue-tinged fluid (2,17). Once the lymphocele is entered, the blue staining of the chamber assists in identification of its extent and the amount of unroofing required.

Excision of the Lymphocele

Laparoscopic shears (Fig. 16.4C) or a harmonic scalpel can be used to unroof the lymphocele, incising through the area of the wall that appears to be the thinnest portion of the structure in a direction parallel to the presumed course of the transplant ureter. After the initial incision, care should be taken to inspect the wall to make sure that structures such as the renal allograft ureter or pelvis, native ureter, or bladder are not injured in the process. In general, only the portion of the wall in contact with the peritoneum is excised, and any of the contained loculations are disrupted bluntly and the walls excised. Although stenting of the transplant ureter can be performed to help in its identification, this can be technically challenging. In a large multi-institutional retrospective study, 81 patients underwent laparoscopic marsupialization, and none of the ureters were stented prior to the laparoscopic surgery, yet no ureteral injuries occurred (3). The wall of the lymphocele can then be excised from the central incision to the edge of the thin region of the wall using the laparoscopic instruments to ballot the area to help judge its thickness and the likely involvement of surrounding structures. The excision is then carried out circumferentially until the entire exposed region of the lymphocele is excised (Fig. 16.4D). Once the segments are excised, they can be removed via the 10/12-mm port or cut into strips prior to removal if they are too large to fit through the port. The specimen is visually inspected, and if any concerning elements are identified, such as portions of ureter, these can be confirmed via frozen section analysis, allowing intraoperative management. If the excised region of the lymphocele is small (<4 cm) and this results in a deep-chambered cavity with a narrow aperture, consideration should be given for placement of an omental wick.

Placement of Omental Wick

Hsu et al. (3), reported that omental interposition was used in only 14% of the 81 reported cases and “was not considered to be an essential prerequisite for long-term success.” Use of an omental tag was recommended only if it could be “readily transposed and affixed to the lymphocele window.” In theory, use of native vascularized tissues to maintain patency of the unroofed portion of the lymphocele will facilitate continued patency and peritoneal drainage of the lymphatic fluids.

The omental interposition graft is usually established using the most distal tip of the omentum, which is isolated; if necessary, the omentum can be divided in a craniocaudad direction to facilitate mobilization. Major vasculature should be left in place, and typically extensive dissection to the margin of the stomach is not required. Once the omentum can be readily affixed to one of the internal walls of the fenestrated lymphocele, several sutures on a small (e.g., RB-1) needle or tacking titanium clips are placed to secure the tip of the mobilized omentum near the base of the lymphocele. Needles for laparoscopic suturing should be introduced and removed via one of the 10/12-mm trocars to prevent their entrapment in the valve mechanism of the port. If the camera port is the only 10/12-mm trocar being utilized for the procedure, this may require switching to a 5-mm laparoscope to use via one of the working ports to allow needles to be introduced into the peritoneal cavity.

In more complex cases of difficult-to-reach lymphoceles, where an omental wick may not be expected to maintain durable patency, laparoscopic marsupialization with placement of peritoneal dialysis catheters cabled together has been utilized to maintain continued lymphoperitoneal flow (18).

Postoperative Care

The patient’s postoperative diet is advanced as tolerated and the Foley catheter is removed once the patient is able to ambulate. In male patients with a history of voiding dysfunction, the Foley catheter is left indwelling until the first postoperative day, and several scanned postvoid residual volumes are evaluated following its removal to ensure adequate bladder emptying. Intravenous pain medication is transitioned rapidly to oral analgesics once the patient is tolerating clear liquids. Laboratory studies are kept to a minimum and individualized depending upon the patient’s clinical condition.

Discharge criteria include toleration of a regular diet, passage of flatus, and pain adequately controlled on oral analgesics. Typically, patients are ready for discharge the same day, or within 24 hours of the procedure; however, the mean hospital stay in a large reported review series was 1.5 days (3).

Outcomes

Hsu et al. (3) noted a lymphocele recurrence rate of 6% over an average of 27 months of follow-up after laparoscopic marsupialization. This compares favorably to the 0% to 15% recurrence rate following open lymphocelectomy reported in the literature (11,17). In a comparison of a group of patients treated with laparoscopic lymphocelectomy to a contemporary group of patients treated via an open approach, Gill et al. (2) reported a statistically significant reduction in blood loss (34.6 versus 117.3 mL), more rapid resumption of oral intake (0.9 versus 2.5 days), shorter hospital stay (2 versus 6.1 days), and more rapid convalescence (2.2 versus 6.9 weeks), respectively. A $7,400 reduction in total hospital costs has also been reported for laparoscopic versus open lymphocelectomy, largely due to the significant reduction in hospital stay (15). It is important to note that more contemporary case series would likely reflect trends toward shorter hospital stays for both of these approaches.

Complications

The reported incidence of complications in one of the largest series of laparoscopic lymphocelectomy was 5% intraoperatively and 4% postoperatively (3). This compares favorably to the 0% to 12% complication rate reported following open lymphocelectomy (2,15,17). One of the most frequently occurring intraoperative complications noted by Melvin et al. (17) was division of the transplanted ureter, which occurred in 7% of their cases. Several methods have been employed to prevent this complication, including ureteral stent placement and insertion of a lighted fiberoptic stent.

The reported incidence of open conversion was shown to be 0% to 36% (15,17). Risk factors for conversion of a laparoscopic to an open approach include prior operations, multiple fluid collections, and unfavorable location of the lymphocele.

CALCULUS DISEASE

U.S. Food and Drug Administration approval of extracorporeal shock wave lithotripsy (ESWL) in 1984 marked a significant paradigm shift in the treatment of urinary tract calculus disease, moving away from open surgery to less invasive techniques. In modern urologic practice, open stone surgery now accounts for <5% of all procedures performed to treat urolithiasis (19,20).

Diagnosis

Imaging with computerized tomography (CT) is the standard today for the identification of urolithiasis. Less commonly, excretory urography, retrograde pyelography, or ureteroscopy is the diagnostic method.

Indications

Technologic advances in the design of endourologic instruments, including ureteroscopes, nephroscopes, baskets, and lithotriptors, including the holmium laser, have all contributed to the great success of minimally invasive stone therapy. Yet infrequent cases exist in which endoscopic or ESWL treatment either has failed or has low expectations for success, and in such cases, surgical stone removal remains a viable option.

Since the introduction of laparoscopic surgery in the early 1990s, urologists have recreated virtually every open stone surgical procedure using laparoscopic techniques. Appropriate patient selection is crucial to ensure that a given patient is amenable to laparoscopic management of such calculi. Some of the indications for laparoscopic stone removal include severely impacted stones (21,22), very large stones >3 cm (23), or complete staghorn stones (24). Although laparoscopy is infrequently utilized for management of urolithiasis, this technique is invaluable when truly indicated, providing a minimally invasive approach to managing select cases of urolithiasis (20,21,25). Laparoscopic stone removal is also often combined with pyeloplasty when concurrent stones are present with ureteropelvic junction obstruction (26).

Alternative Therapy

As noted, ESWL, ureteroscopic, or percutaneous techniques are the preferred standard for the management of urolithiasis. Open ureterolithotomy is another alternative to the laparoscopic approach. Robotic surgery, particularly due to reconstructive capabilities, has been reported for large renal stones, with and without concomitant ureteropelvic junction repair (27,28).

Surgical Technique

The precise location of the stone must be identified with preoperative imaging. Noncontrast CT provides detailed anatomic information. The planned approach for appropriate trocar placement will depend on the location of the stone and can be categorized as either *upper*, which includes calculi in the renal pelvis and the upper ureter (above the pelvic brim) (Fig. 16.5), or *lower*, for calculi in the ureter distal to the pelvic brim.

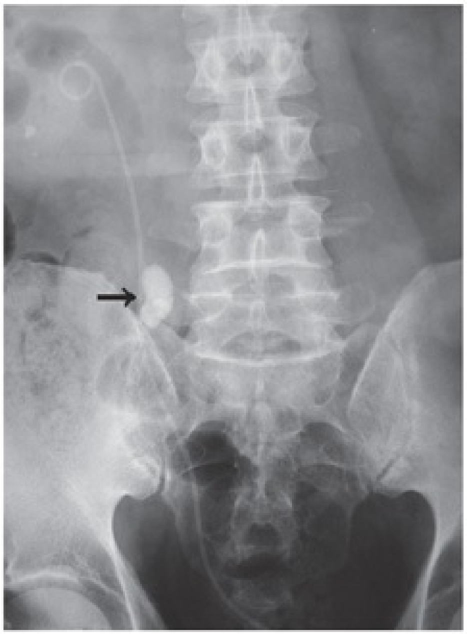

FIGURE 16.5 X-ray shows a very large calculus (*arrow*) impacted in the upper portion of the right ureter.

Placement of a ureteral stent is often required to manage large or impacted stones. To facilitate intraoperative placement of a ureteral stent, cystoscopy with ureteral catheterization should be performed at the onset of the case. If a guide wire can be manipulated past the stone, this will aid the stent placement; if a wire cannot bypass the stone, an open-ended ureteral catheter is advanced up to the level of the stone. This provides a conduit for passing a wire after the stone is removed and may help identify the ureter during the laparoscopic dissection portion of the procedure. A urethral Foley catheter is placed to drain the bladder and a suture used to secure the ureteral catheter, both of which are prepared into the operative field during laparoscopy.

Upper Stones

The patient is placed in a modified lateral recumbent position with the ipsilateral side elevated with a beanbag or kidney rest. The patient is secured to the operating room table with 3-inch silk tape across the chest, waist, and legs. The abdomen is entered with either the Veress needle or the Hasson method, at the surgeon's discretion. Port placement is similar to that used for pyeloplasty, with the camera port placed at the umbilicus. The two operating ports can be placed either in the midline, superior and inferior to the umbilical port, or lateral to the midline and 45 degrees to either side of a "line" from the camera port toward the renal pelvis or ureteral stone location (19). The axis of balance is a line joining the camera trocar to the location of the calculus. The accessory or working trocars are placed with this axis in mind (Fig. 16.6).

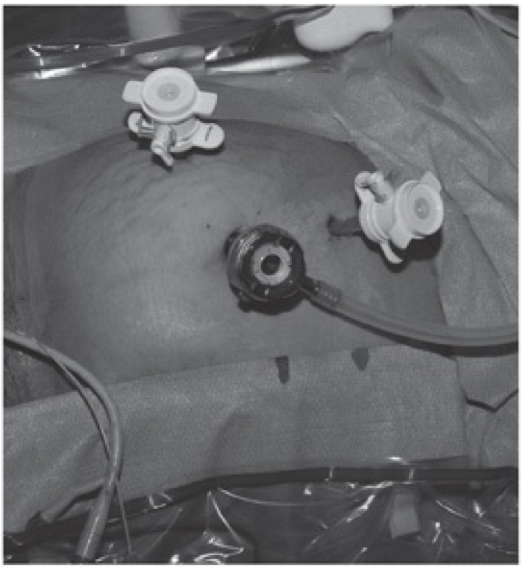

FIGURE 16.6 Patient positioned for right laparoscopic ureterolithotomy. The camera is placed in the umbilical trocar. This configuration can also be used for laparoscopic right ureterolysis, also described in this chapter.

The colon is reflected along the white line of Toldt and is allowed to fall medially, aided by airplane rolling the bed, if needed. The ureter is identified and traced to the renal pelvis or until the stone is encountered. For a ureteral stone, since the proximal ureter is usually dilated or tortuous, placement of vascular tape or a vessel loop around the ureter proximal to the stone can help prevent proximal stone migration. The ureter or renal pelvis is opened with either shears or a laparoscopic scalpel handle (Aesculap, Center Valley, Pennsylvania). The stone should be removed in one piece when possible and may have to be extracted with the use of an Endo Catch bag at the end of the procedure. A guide wire can be placed retrograde through the preplaced ureteral 5Fr open-ended catheter, followed by placement of a double-pigtail ureteral stent. The incision in the ureter or pelvis is closed laparoscopically with a 4-0 polyglactin suture (continuous or interrupted) and a closed suction drain is left in place until output subsides.

Lower Stones

For stones in the lower portions of the ureter, the patient may be left in a supine position. The peritoneum is again entered at the choice of the surgeon with the camera port placed at the umbilicus. The axis between the camera trocar and the stone is marked, and the two operating ports are then placed under direct vision on either side of the body just lateral to the rectus muscles. The surgeon stands on the contralateral side of the patient and begins the dissection at the level of the bifurcation of the common iliac vessels. The ureter is followed proximally or distally until the stone is located. The surgical procedure proceeds in a similar fashion as described earlier. For stones located in the midureter, the colon may need to be mobilized for exposure, which may be assisted by a gentle airplaning of the table to the contralateral side.

Postoperative Management

The Foley catheter is left in place for 48 hours to maintain a low-pressure drainage of the urinary tract. This will expedite removal of the peri-incisional drain. The ureteral stent can be removed with the use of a cystoscope in 2 to 4 weeks.

Outcomes

This procedure is not commonly performed and is practiced more commonly outside the United States. Success rates of over 94% are reported (29).

Complications

All standard laparoscopic surgical complications are possible, including infection, bleeding, and conversion to an open surgical procedure. Prolonged urinary leakage and urinary stricture are possible.

LAPAROSCOPIC VARICOCELE LIGATION

Dilation of the pampiniform plexus of veins draining from the testicles is encountered in up to 15% of the general male population and in 40% to 70% of men undergoing evaluation for infertility. Laparoscopic varicocele ligation closely resembles the retroperitoneal approach first described by Palomo in 1948 (30). More recently, LESS laparoscopic varicocelectomy has been applied with a tendency toward improved cosmesis and postoperative pain (31).

Indications for Surgery

Indications for surgical correction include infertility with poor-quality semen, decrease in testicular size, and chronic pain or discomfort from a large varicocele. A failed previous attempt at retroperitoneal repair is a contraindication to laparoscopic varicocele ligation. The ultimate choice of varicocele ligation method is determined by surgeon preference and experience as well as patient-specific factors.

Alternative Therapy

Several different surgical techniques have been described with inguinal (Ivanissevitch), subinguinal microscopic (Marmar–Goldstein), and open retroperitoneal or high ligation techniques (Palomo) approaches. Microscopic techniques are becoming more commonly used to reap the benefits of a less invasive procedure and reduced incidence of hydrocele. Embolization may also be used.

Surgical Technique

Most surgeons utilize the transperitoneal approach, with some reports of successful laparoscopic extraperitoneal varix ligation. The patient is placed in a supine position and the peritoneum entered at the umbilicus with either the Veress needle or Hasson technique. After creation of pneumoperitoneum, the table is rotated, and the additional operative trocars are placed under direct vision.

Two separate trocar templates exist. The first places one port just inferior to the umbilicus and lateral to the rectus muscle on the ipsilateral side, with the second port infraumbilical in the midline. The second template places both operative trocars just lateral to either edge of the rectus muscle and slightly inferior to the umbilicus. The latter allows for bilateral procedures to be performed if necessary (Fig. 16.7).

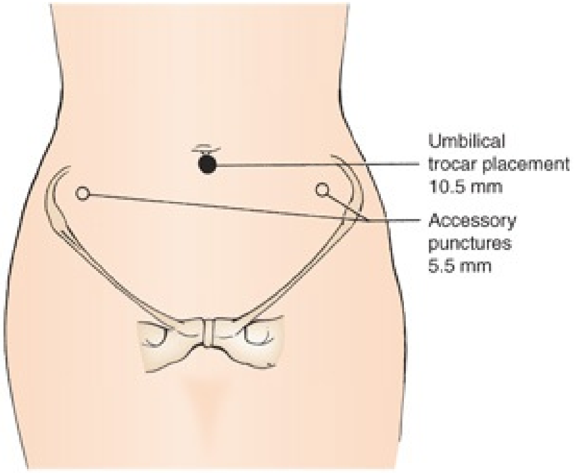

FIGURE 16.7 Appropriate position of trocars for varix ligation. The array of trocars is used in either left or bilateral varix ligation. The subumbilical trocar is either a Hasson cannula for open laparoscopy or a standard trocar inserted following Veress needle insufflation. The operating trocars are 5.5 mm when a 5-mm clip applier is available or 10 mm when one must rely upon a 10.5-mm hemoclip applier.

Once the ports are placed, attention is turned to the internal inguinal ring, and the nearby iliac vessels, vas deferens, and medial umbilical ligament are all identified (Fig. 16.8). If the colon obscures the internal ring, it should be mobilized by incising the line of Toldt or placing the patient in slight Trendelenburg position. The magnification afforded by the laparoscope aids in the visualization of the spermatic vessels running beneath the peritoneum.

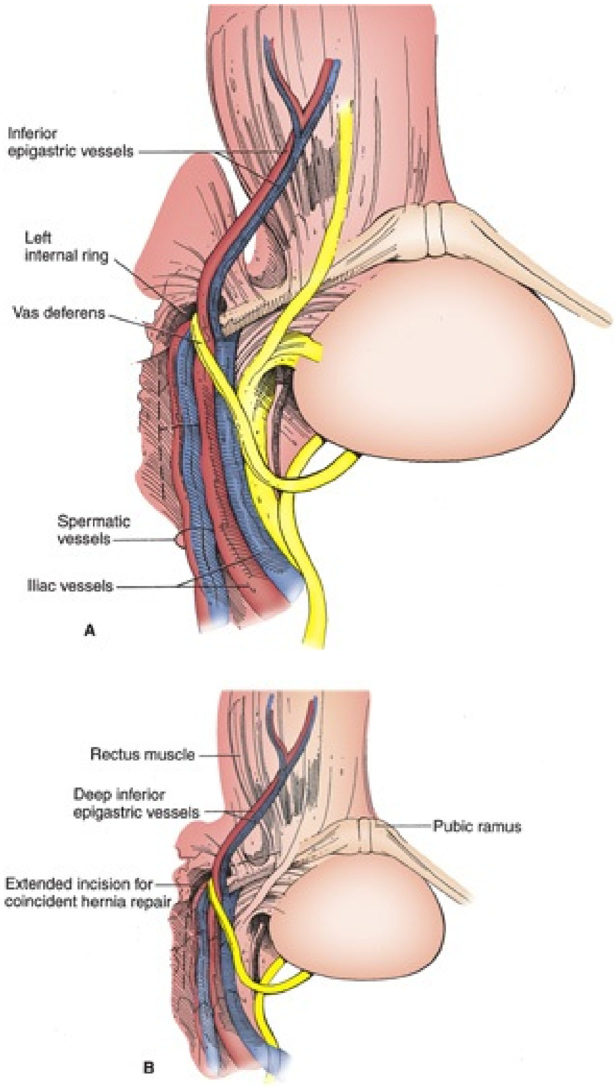

FIGURE 16.8 A 3- to 5-cm incision through the peritoneum is made lateral to the spermatic vascular bundle; it extends cephalad from a point 3 to 5 cm above the internal ring.

The peritoneum is incised lateral to the spermatic cord (see Fig. 16.8) and the testicular artery and veins are dissected free. If identified, the testicular artery should be preserved. Use of electrocautery should be restricted so as not to cause thermal injury to the artery. The use of papaverine liquid over the vessels will assist in dilation of the artery, subsequent pulsations, and easier identification of the artery. The intraoperative laparoscopic Doppler probe is helpful to identify the artery. Arterial preservation is not a requirement. The cremasteric and deferential collateral circulations are not jeopardized by the laparoscopic approach and are usually sufficient to maintain the viability of the testicle. The dissection and ligation is described in Figures 16.9 to 16.11. The vessels may be ligated with titanium clips, the endovascular stapler, or intracorporeal knot tying. After ligation, they are transected, completing the procedure. Alternatively, a bulk ligation of the cord with a 2-0 silk or stapler can be performed without regard to preserving the artery. It may be useful to divide the cord into smaller packets without regard to the spermatic artery preservation.

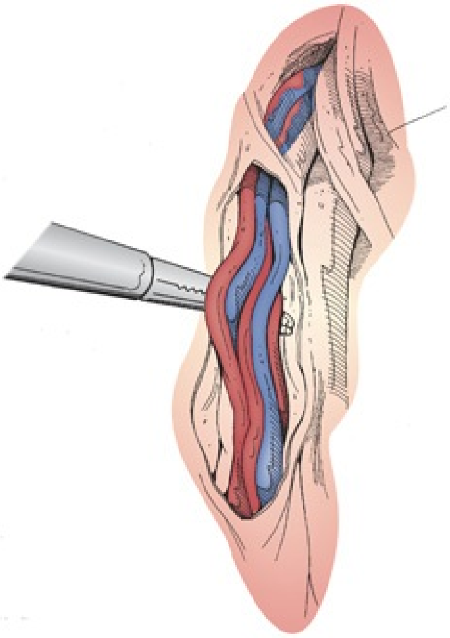

FIGURE 16.9 The entire spermatic vascular bundle is mobilized from the underlying psoas muscle. A combination of sharp and blunt dissection facilitates separation of the spermatic vessels from surrounding tissues. One should avoid deep dissection in order to spare the underlying genitofemoral nerve crossing anterior to the psoas muscle.

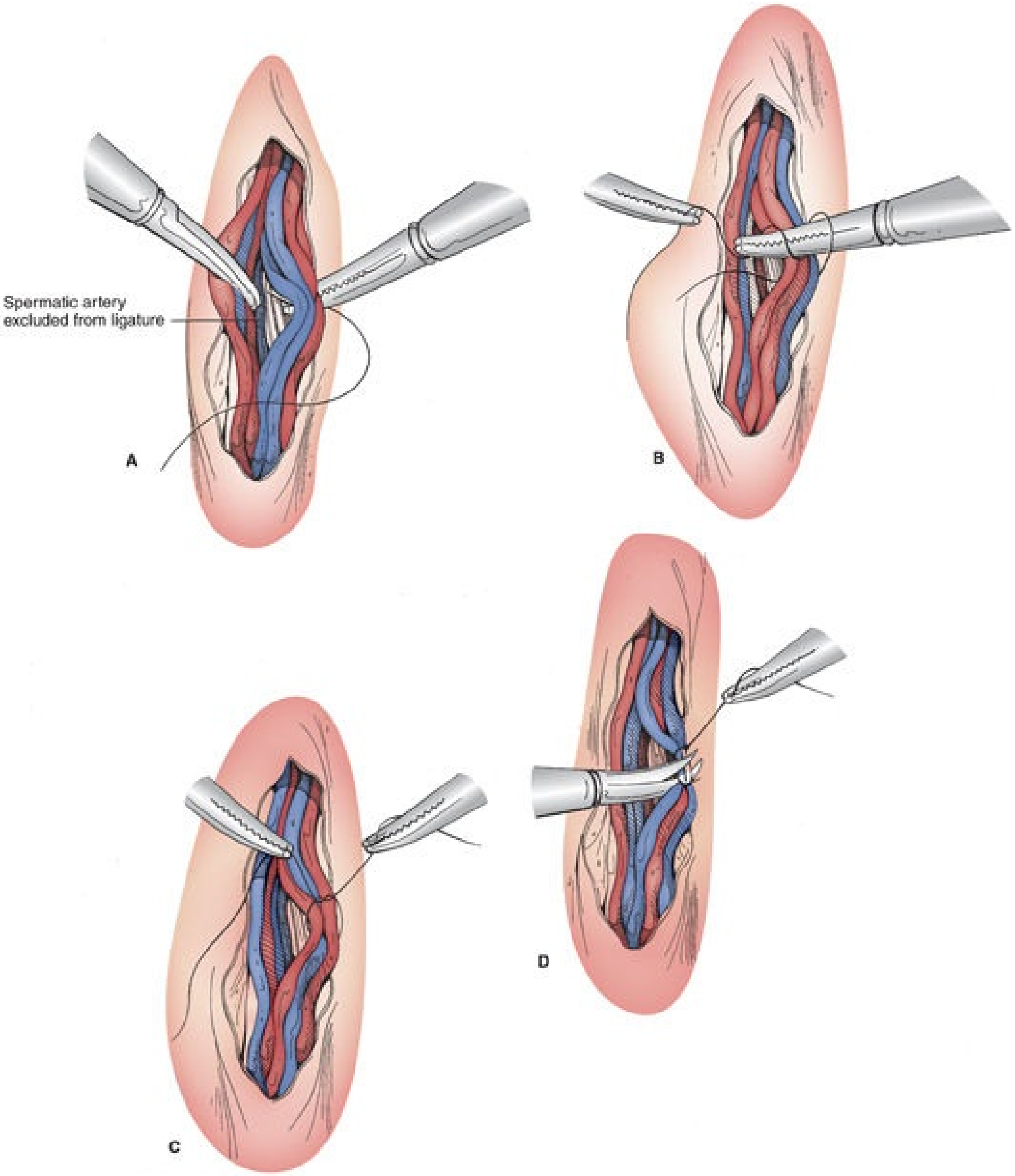

FIGURE 16.10 **A:** When performing an artery-sparing varix ligation, the vascular bundle that does not contain the spermatic artery is ligated and then divided. For small venous aggregates or single spermatic veins, the 5-mm reusable clip or suture ligature is utilized based on surgeon preference. A 5- to 10-cm ligature is passed into the abdominal cavity. One end is passed from right to left under the vessels to be ligated, extending only 1 cm beyond the vessels. The other end is long to facilitate instrument tie. **B:** The long end is grasped by the left-hand instrument, allowing sufficient slack to permit easy wrapping around the tip of the right-hand instrument. The instrument tie can be accomplished with two curved dissectors with tips rotated up. Alternatively, instruments specifically designed for laparoscopic suture and ligation may be used. **C:** The nonarterial vascular bundle is ligated. **D:** The spermatic veins are divided between ligatures.

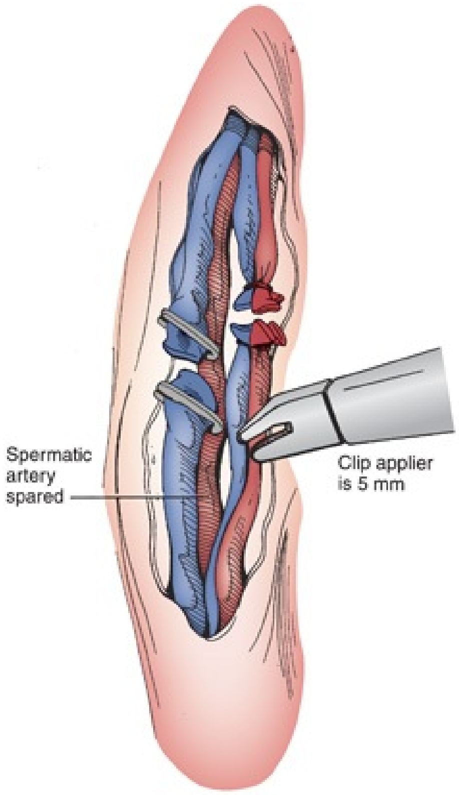

FIGURE 16.11 Upon completion of the procedure, all spermatic veins have been ligated and divided by either clip or suture. Only the spermatic artery or arteries remain, and arterial patency is documented by Doppler.

If scrotal emphysema is present, we eliminate it with brief compression before final port removal. Standard laparoscopic closure techniques are followed. Patients are discharged on the day of surgery without restrictions in physical activity.

Outcomes

Operative times vary based upon extent of operation (unilateral or bilateral), complexity of repair (artery sparing takes longer than artery sacrifice), and laparoscopic experience (novice takes longer than expert). With experience, non–artery-sparing procedures will last 15 to 30 minutes and artery-sparing procedures will last 45 to 60 minutes. A randomized trial comparing open to laparoscopic varix ligation revealed similar outcomes in terms of efficacy and complications, but advantages in terms of pain and recovery time (32). Results indicate that spermatic arterial ligation did not influence response and did not result in testicular atrophy.

Complications

Due to the age group involved, perioperative complications are very rare. Potential complications include bleeding, a need to convert to an open procedure, infection, testis atrophy or loss, and failure to correct the varicocele. Even with successful correction of the varicocele (i.e., absence of a palpable varix at 6 months following surgery), signs and/or symptoms that prompted the operation (orchalgia, oligoasthenospermia) may persist.

LAPAROSCOPIC URETEROLYSIS

Ureteral stenosis or strictures can be caused by a variety of intrinsic as well as extrinsic causes. Thus, ureteral strictures can be caused iatrogenically, such as post-ureteroscopy or following other surgical procedures in close proximity to the ureter. Stenosis may also be secondary to conditions such as retroperitoneal fibrosis (RPF) or extrinsic tumors. The clinical features include flank pain, abdominal pain, renal failure, as well as signs and symptoms of urinary tract obstruction, bacteremia, etc.

RPF is an inflammatory process involving the retroperitoneum that results in excessive fibrosis and often causes ureteral entrapment, compression, and obstruction leading to hydronephrosis. The primary, idiopathic etiology accounts for 70% of the cases, with the remainder of cases occurring secondarily in response to numerous conditions, including vascular aneurysm with or without grafting; radiation exposure; inflammatory bowel disease; malignancy; or drug exposure, including use of beta-adrenergic blockers or ergot alkaloids.

The most common presentation is colicky flank pain from ureteral obstruction; however, the fibrosis may be so extreme as to entrap the great vessels or renal vasculature, so that lower extremity edema, hypertension, or hematuria may also occur. On the other hand, ureteral strictures may be asymptomatic and can present with painless hydronephrosis (29,33,34).

Diagnosis

Preoperative imaging may consist of intravenous pyelography or CT scans, typically demonstrating hydronephrosis and medial deviation of the course of the ureter, either unilaterally or bilaterally. Retrograde pyelograms performed just prior to ureterolysis may provide updated information regarding the course of the ureter and help identify the extent (length) of ureteral entrapment.

Indications for Surgery

Ureterolysis can be both diagnostic, allowing for biopsy of the retroperitoneal mass, and therapeutic, allowing release of the ureters.

Alternative Therapy

Traditionally, ureterolysis is performed by the open surgical approach, often with a large midline incision. Many centers will attempt a trial of steroids or selective estrogen modulator such as tamoxifen empirically before surgical correction. Malignant RPF can sometimes be managed primarily by chemotherapy without the need for ureterolysis (29,33). Laparoscopic ureterolysis has the obvious cosmetic advantages compared to the open approach, and some studies suggest the added benefits of a shorter hospital stay, decreased analgesic use, and decreased transfusion rates (35,36). Recently, robot-assisted laparoscopic ureterolysis with omental wrap has been described (37,38).

Surgical Technique

Ureterolysis

Laparoscopic ureterolysis begins with cystoscopy and retrograde placement of either a double-pigtail stent or a ureteral catheter to aid in identification of the ureter during laparoscopy. Either a regular 5Fr open-ended or lighted catheter may be used. To further aid ureteral delineation from the surrounding dense fibrotic tissue, a super-stiff guide wire may also be placed inside a ureteral catheter (34). Similar to laparoscopic pyeloplasty positioning, the patient is placed in a lateral decubitus position with the ipsilateral side elevated to allow gravity retraction of the bowels. If a bilateral ureterolysis (29,33,34) is planned, the patient may either be left supine or repositioned (this is recommended) after completion of the first side.

The template for port placement will vary depending on the extent of fibrosis and the levels of the ureter involved. A standard pyeloplasty template (see earlier under calculus management) may be sufficient for isolated upper ureteral involvement, but additional ports may be necessary to free the entire ureter.

After creating pneumoperitoneum and rotating the patient, the colon is mobilized along the white line of Toldt and allowed to fall medially. When necessary, this incision is extended over the iliac vessels to allow exposure of the full course of the ureter. Depending on the extent of RPF, the ureters are often retracted medially and may be overlying the great vessels entrapped in dense fibrous scars, making localization difficult.

If a ureteral catheter was placed, gentle manipulation may help locate the ureter. Alternatively, the distal ureter may be encountered medial to the medial umbilical ligament and traced proximally, or the proximal ureter may be isolated at the ureteropelvic junction and dissected distally. Once positively identified, a window is created around the ureter and vascular tape or a vessel loop is placed around to allow retraction without undue manipulation of the ureter. Combinations of blunt, sharp, and electrocautery dissection are necessary to liberate the ureter from surrounding fibrosis, although the latter should be used sparingly to avoid vascular compromise. For patients with RPF, after the ureter is mobilized, it should be intraperitonealized, and after this is accomplished, the posterior peritoneum is closed with clips or preferably with sutures. Laparoscopic omental wrap can be performed to further isolate the ureter using a variety of techniques as described by Stein et al. (39). If a ureteral catheter was placed at the onset, it should be exchanged for an indwelling self-retaining ureteral stent at this time. Special efforts must be made to rule out malignancy as the underlying cause of the fibrosis, and multiple biopsies are taken from periureteral tissues and sent for both frozen and permanent analysis.

Laparoscopic ureterolysis is also amenable to hand-assisted laparoscopic approaches and has also been reported using robotic techniques. The principles of ureterolysis can be followed with the use of the intra-abdominal hand to assist in identification and dissection of the ureter (33). Robot-assisted laparoscopic ureterolysis has been shown to compare favorably with the pure laparoscopic technique, with the theoretical advantages inherent to robotic surgery (37,38).

Management of Ureteral Strictures

For benign, iatrogenic or idiopathic ureteral strictures, the strictured ureteral segment is excised. Caution should be exercised around the iliac vessels and the inferior vena cava so as to prevent vascular injury. The ureteral ends are then spatulated. The posterior walls of the ureteral ends are anastomosed using 4-0 polyglactin sutures. A ureteral stent is then placed in a retrograde fashion utilizing the 5Fr open-ended ureteral catheter, which is removed after a guide wire is placed through it. The anterior end-to-end anastomosis of the ureteral ends is now completed. A closed-suction drain is placed. A Foley catheter drains the bladder postoperatively to maintain a low-pressure urinary drainage system.

If the ureteral stricture is long, and if the anastomosis is under tension, then the management strategy may involve further laparoscopic ureterolysis to ensure a tension-free anastomosis. Rarely, one may have to utilize procedures such as nephropexy to enable a tension-free end-to-end ureteroureterostomy.

Postoperative Management

The Foley catheter is usually left indwelling for 48 hours. The drain is kept in place for another day or two, then removed. The indwelling stent is removed using a flexible cystoscope 4 to 6 weeks postoperatively. Postoperative imaging is recommended to evaluate for any residual or silent recurrence of the hydronephrosis.

Outcomes

A recent multicenter review indicated overall success rates of 83% per renal unit (29). This was confirmed by follow-up imaging in these cases. Other institutional series are also favorable (29,33,35).

Complications

Any complication that can be associated with laparoscopy, including conversion to an open procedure, has been reported. One series reported a conversion rate to open of 17.6% (35).

ACKNOWLEDGMENTS

Prior contributing authors for this content: Gordon L. Fifer and Raju Thomas

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SECTION II ■ BLADDER

Section Editor: STEPHEN J. SAVAGE

CHAPTER 17 ■ ANATOMY OF THE BLADDER

CLINTON W. COLLINS AND ADAM P. KLAUSNER

GENERAL DESCRIPTION

The bladder is a hollow, muscular retroperitoneal organ with a capacity of 400 to 500 mL in the normal adult. The bladder is a pelvic organ when empty, lying behind the pubic symphysis. However, when distended, it can be palpated above the pubic symphysis and can protrude well into the abdomen during an episode of severe urinary retention.

PERITONEAL RELATIONSHIPS

The peritoneum covers the superior and a portion of the posterior bladder. In females, the peritoneum continues posteriorly onto the surface of the uterus and rectum, establishing the vesicouterine and rectouterine pouches, respectively (Fig. 17.1) (1). In the male, the peritoneum continues along the surface of the rectum, establishing the rectovesical pouch of Douglas. The two leaves of the peritoneum embryologically coalesce to form the anterior and posterior layers of Denonvilliers fascia (rectovesical fascia), a critical landmark in the performance of a radical retropubic prostatectomy (Fig. 17.2) (2).

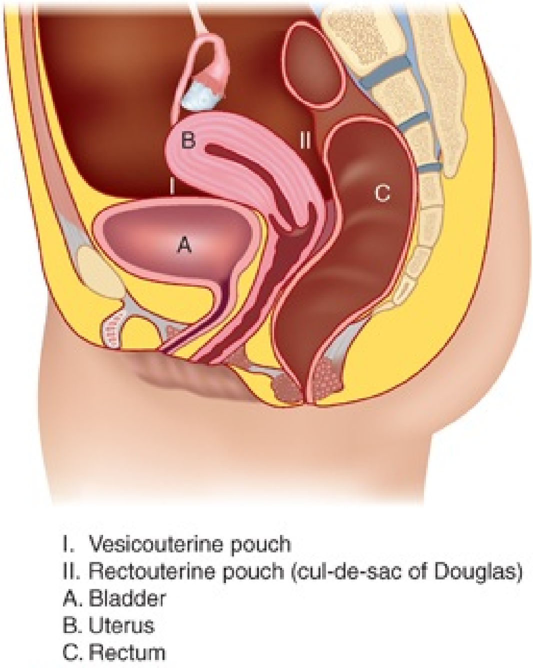


FIGURE 17.1 Sagittal view of female pouches.

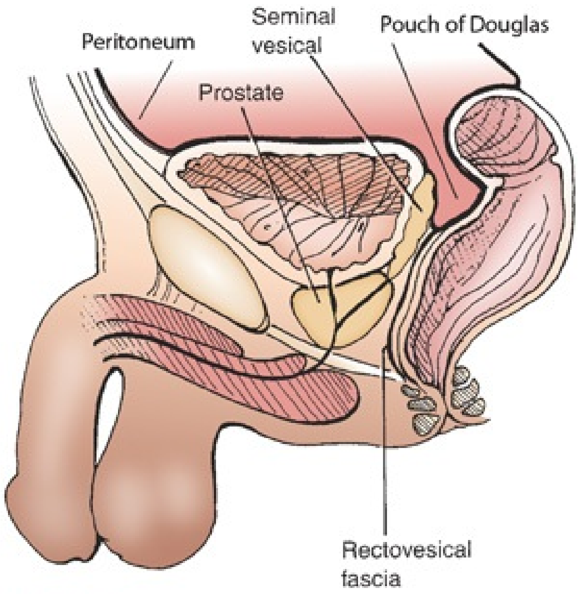


FIGURE 17.2 Lateral view of the male pelvis showing the peritoneal reflection and the pouch of Douglas.

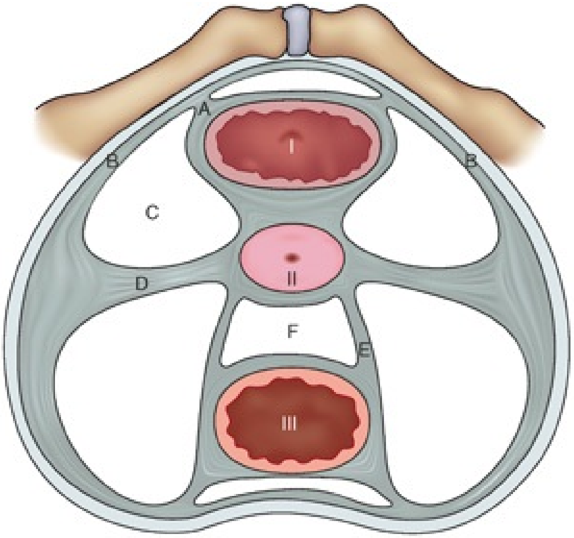
PERITONEAL FOLDS

As seen from a typical laparoscopic approach to the abdominal cavity, the anterior surface of the peritoneum has three characteristic deflections, also called folds. The midline fold is called the *median umbilical ligament* and the paired paramedian folds are called the *medial umbilical ligaments*. Fortunately, the anatomy itself is less confusing than the terminology. In relation to the bladder, the median umbilical fold is the most important of these structures as it contains the urachal ligament. Attaching to the bladder anteriorly at its dome, this ligamentous structure, containing fatty and vascular tissue, tethers the bladder to the umbilicus. This structure, which represents the obliterated urachus, contains paraumbilical veins and must be ligated when divided during surgical exposure of the bladder. The bladder muscle, also called the detrusor, is attenuated where the urachal ligament attaches, predisposing this area to the formation of diverticula. Retropubic and perivesical fat is present anteroinferior and lateral to the bladder.

LIGAMENTOUS ATTACHMENTS

In the pelvis, the bladder is supported anatomically by two types of ligaments: fibroareolar (true) ligaments and peritoneal folds. True ligaments provide support for the bladder laterally via the lateral ligament of the bladder and posteriorly via the vesicovenous plexus. The lateral ligament derives from the transversalis (endopelvic) fascia as it courses over the levators and attaches the bladder to the tendinous arch of the endopelvic fascia. This ligament contains the inferior vesical and vesicodeferential arteries in the lateral extensions as well as the pudendal plexuses of nerves and vessels. In addition, in males, this ligament contains the vasa deferentia. The posterior ligaments provide posterolateral support to the bladder. These ligaments are connective tissue condensations in which the vesical venous plexus drains into the internal iliac veins. Peritoneal folds also connect the bladder to the pelvic sidewalls and consist of the median, medial, and lateral umbilical folds as well as the sacrogenital folds. The median umbilical fold and medial umbilical folds originate at the bladder and terminate at the umbilicus. They contain the urachus and the obliterated umbilical arteries, respectively. The lateral umbilical folds attach the bladder to the pelvic sidewalls and contain the inferior epigastric arteries. The sacrogenital folds connect the bladder to the sacrum (Fig. 17.3)

(3).

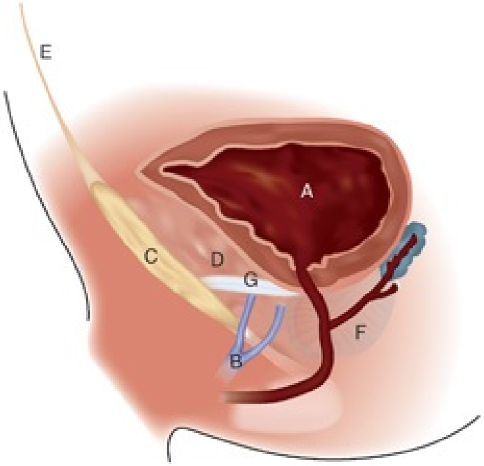


A. Pubovesical ligament
B. Archus tendineus levator ani
C. Endopelvic (pubocervical) fascia
D. Cardinal ligament
E. Uterosacral ligament
F. Rectouterine pouch (cul-de-sac of Douglas)

I. Bladder
II. Uterus
III. Rectum

FIGURE 17.3 Axial view of the female pelvis illustrating the ligamentous supports of the bladder.

The bladder is also fixed to the symphysis pubis by the pubovesical ligaments in females and the puboprostatic ligaments in males. The dorsal vein of the clitoris or penis passes between these paired ligaments. These ligaments represent an important surgical landmark as they form the anteromedial portion of the retropubic space, also called the space of Retzius. The space of Retzius is bound anteriorly by the transversalis fascia, inferiorly by the puboprostatic (pubovesical) ligaments, and infralaterally by the lateral ligaments of the bladder (Fig. 17.4).



A. Bladder
B. Dorsal vein of penis
C. Pubic tubercle
D. Retropubic space of Retzius
E. Transversalis fascia
F. Prostate
G. Puboprostic ligament

FIGURE 17.4 Lateral view of a portion of the male pelvis showing the space of Retzius. The space of Retzius is bound anteriorly by the transversalis fascia, inferiorly by the puboprostatic (pubovesical) ligaments, and infralaterally by the lateral ligaments of the bladder.

HISTOLOGIC STRUCTURE

The lumen of the bladder is lined by transitional epithelium, also called urothelium. This unique epithelium is characterized by its outer layer of umbrella cells, which are sealed closely together and communicate via tight junctions. The term *transitional* denotes the ability of these outer cells to undergo significant transitions in shape depending on the state of bladder filling. Thus, the cells are puffy and cuboidal when the bladder is empty and become flat and elongated when the bladder is distended (4). Beneath these umbrella cells, the transitional epithelium contains additional layers of cells (usually about seven) and a distinct layer of basal cells. Deep to the transitional epithelium lies the lamina propria, composed of fibroelastic connective tissue through which vessels course. Wisps of smooth muscle also course within the lamina propria, and this portion of the lamina propria is sometimes referred to as the muscularis mucosa (Fig. 17.5).

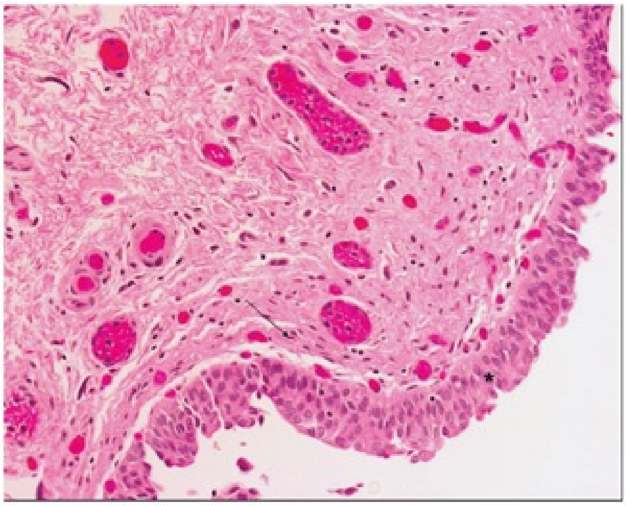


FIGURE 17.5 Microscopic image of normal bladder. Note wisps of smooth muscle (*arrow*) within the lamina propria (*asterisk*).

The distinction between the muscularis mucosa and muscularis propria or true muscular layer of the bladder that lies deep to the lamina propria is critical in the staging and prognosis of urothelial cancer. Cancer that is confined to the urothelium or lamina propria, even when surrounded by wisps of muscularis mucosa, is considered superficial disease and is mainly treated via local resection or with intravesical immuno- or chemotherapeutic agents. However, cancer that penetrates into the muscularis propria, characterized histologically by large, distinct detrusor smooth muscle bundles (Fig. 17.6), is considered invasive cancer and is treated more aggressively, usually requiring surgical removal of the entire bladder or bladder-preserving chemoradiation. Within the muscularis propria, detrusor smooth muscle bundles course in inner longitudinal, middle circular, and outer longitudinal orientations. In addition, interstitial cells surround and percolate within the muscle bundles and may be important in maintenance or modulation of bladder muscle tone (5). These muscle layers are less distinct in the upper aspect of the bladder. However, they become quite prominent at the bladder neck, although composed of finer fibers. In males, the middle layer of circular detrusor smooth muscle forms a preprostatic layer that has robust expression of alpha receptors (mainly alpha 1a) and contributes to continence at the bladder neck. Furthermore, the success in treatment of benign prostatic hyperplasia with alpha blockers stems, in part, from a pharmacologic reduction in tone in the smooth muscle surrounding the prostate and bladder neck (6). In females, the bladder neck differs dramatically, with a less distinct middle layer of smooth muscle (1,7).

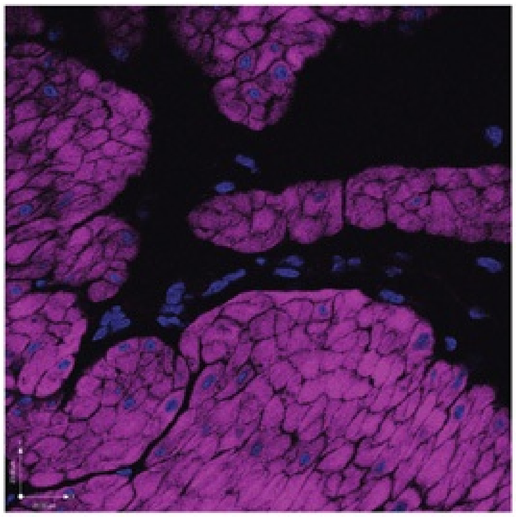


FIGURE 17.6 Confocal immunohistochemical imaging showing detrusor bundle. Detrusor bundle is stained purple with phalloidin, which binds actin in detrusor smooth muscle cells. Nuclei within detrusor smooth muscle bundles and nuclei within interstitial cells are stained blue with DAPI, which binds strongly to DNA.

URETERAL VESICAL JUNCTION AND TRIGONE

The spiral fibers of the ureter become more longitudinally oriented near the bladder and are encased in the fibromuscular Waldeyer sheath from a distance just proximal to its entrance into the bladder wall through its course to the trigone (1,8). Obliquely, the ureters enter the bladder posteroinferiorly and course approximately 2 cm toward the ureteral orifice, narrowing as the intramural ureter is compressed by the detrusor of the bladder surrounding it. The ureter lies just beneath the bladder mucosa with a muscular layer backing (1).

A distinct landmark is formed at a triangle located between the ureteral orifices and the bladder neck, referred to as the bladder trigone. Layers of ureteral and bladder smooth muscle coalesce here as a raised ridge of tissue between the two orifices referred to as the interureteric ridge. This ridge is helpful in identifying the ureteral orifices endoscopically (Fig. 17.7). The trigone is composed of three distinct layers: (a) a superficial layer derived from the longitudinal layer of ureteral smooth muscle; (b) a deep layer that is continuous from Waldeyer sheath, inserting at the bladder neck (Fig. 17.8); and (c) the detrusor layer, derived from the outer longitudinal and middle circular layers of smooth muscle (1). The unique anatomic structure of the intramural ureter and trigone contributes to the intrinsic antireflux mechanism, which prevents vesicoureteral reflux during bladder filling and voiding.

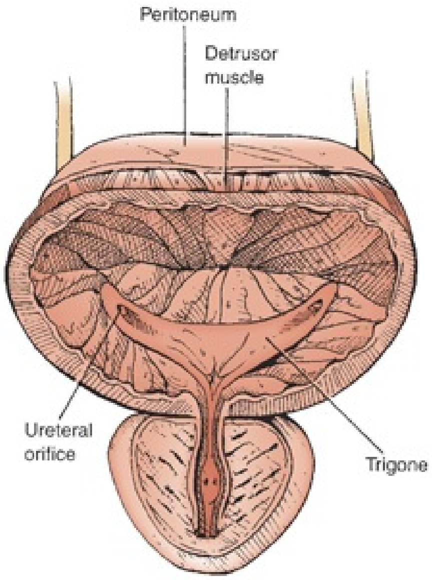


FIGURE 17.7 Anterior view of the bladder of a male opened and demonstrating intravesical anatomy. Note the trigone continues into the prostatic urethra.

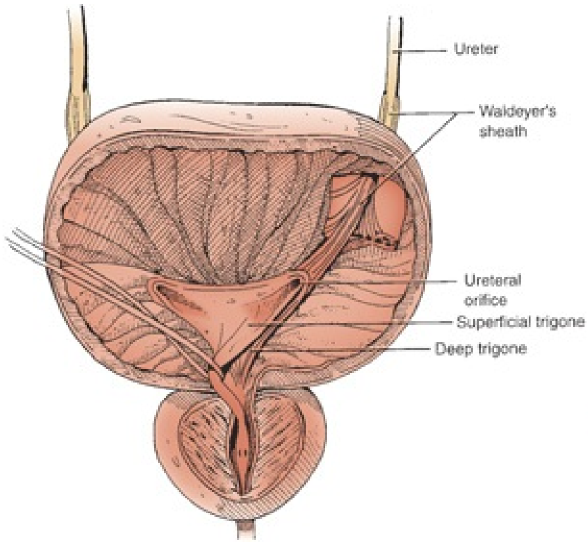


FIGURE 17.8 Lateral view of ureter as it enters the bladder via the intramural tunnel. Note Waldeyer sheath extends from the bladder to encase the distal ureter just proximal to the bladder and fuses to the ureteral musculature. Waldeyer sheath is a continuation of the deep trigone and connects by a few fibers to the detrusor muscle at the ureteral hiatus.

BLOOD SUPPLY

Multiple blood vessels supply the urinary bladder; however, the exact vascular anatomy can vary somewhat between individuals. Less variable is the presence of two more distinct collections of vessels referred to as the lateral and posterior pedicles (Fig. 17.9). In the male, the lateral and posterior pedicles are also called the lateral and posterior ligaments. In the female, these vascular pedicles are part of the cardinal and uterosacral ligaments. The blood vessels within these pedicles branch from the superior and inferior vesical arteries. The superior vesical artery arises from the internal iliac close to its origin from the common iliac. It can also arise as a branch from the umbilical artery, which branches off of the proximal internal iliac. The inferior vesical artery branches off of the internal iliac artery at a more distal location. However, it is important to recognize that the arterial supply to the bladder may arise from *any* portion of the internal iliac. In terms of venous drainage, veins from the bladder drain predominantly into lateral plexi and then empty into veins within the lateral prostatic ligaments and ultimately into the internal iliac veins (1).

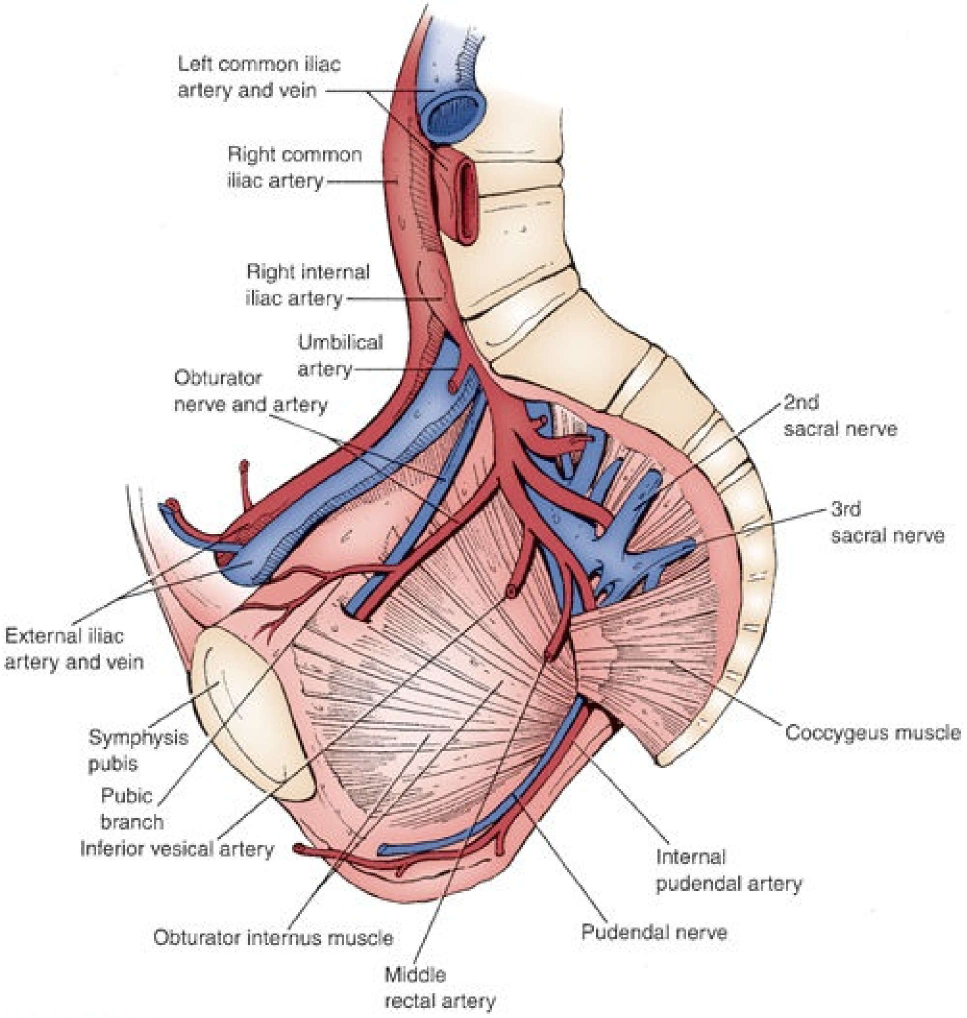


FIGURE 17.9 Lateral pelvic side wall demonstrating the vasculature and innervation of the deep pelvis. The arterial supply of the bladder is from the superior lateral vesical artery and the inferior vesical artery enclosed in the posterior pedicle.

INNERVATION

Sensory Innervation

In the bladder, there are two types of sensory (afferent) nerve fibers: alpha-delta and C fibers. Alpha-delta fibers are partially myelinated and carry information to the central nervous system regarding bladder fullness and wall tension. These sensory fibers are responsible for initiating the normal voiding reflex. On the other hand, C fibers are unmyelinated nociceptive fibers that mainly carry information to the central nervous system regarding noxious or painful stimuli. Although these C fibers comprise about 70% of the total afferent nerves supplying the bladder, they are generally silent and only become sensitive during inflammation, irritation, or suprasacral spinal cord injury. Prolonged activation of C fiber afferents may be responsible for the development of pathologic voiding reflexes associated with some forms of overactive bladder.

Sensory or “afferent” fibers from the bladder are contained in the pelvic, hypogastric, and pudendal nerves. Afferent fibers in the pelvic and pudendal nerves enter the sacral spinal cord via dorsal root ganglia, with the most prominent projection passing anterolateral toward the sacral parasympathetic nucleus. Afferent fibers in the hypogastric nerves also enter the spinal cord via dorsal root ganglia in the lumbar spinal cord. Afferent fibers from the external urethral sphincter pass through Onuf nucleus in the sacral spinal cord.

Motor Innervation

Motor innervation to the bladder arises from three sets of nerves: (9) the *parasympathetic* sacral (pelvic) nerve, arising from the sacral spinal cord between S2 and S4; (6) the *sympathetic* thoracolumbar (hypogastric) nerve, arising from the spinal cord between T10 and L2; and (10) the *somatic* pudendal nerve, which also arises between S2 and S4. In humans, parasympathetic preganglionic motoneurons reside in the sacral intermediolateral cell group in the sacral cord segments at S2–S4, and their axons reach the bladder via pelvic nerves (11,12). In the cat and human, the motoneurons to the external urethral sphincter (EUS) are located in Onuf nucleus in the ventral horn at the level S1–S2 of the spinal cord (13,14).

THE MICTURITION REFLEX

Pontine Micturition Center

Barrington (9) helped define a crucial structure of the micturition reflex located in the dorsolateral pons by showing that bilateral lesions in this area in the cat result in urinary retention. This area is known as the pontine micturition center (PMC), Barrington nucleus, or the M-region. The PMC projects to the sacral parasympathetic nucleus located in the sacral intermediolateral cell column and to the sacral intermediomedial cell column or dorsal grey commissure (DGC) (15).

Stimulation of the PMC causes detrusor contraction via synapses located in the aforementioned intermediolateral cell column from S2 to S4, and this signal travels to the bladder via pelvic nerves (16). Stimulation of the PMC also causes relaxation of EUS (15,17).

Damage to the spinal cord between the sacral motor outflow and the PMC leads to a characteristic pattern of neurogenic detrusor overactivity (involuntary contractions) and detrusor external sphincter dyssynergia (lack of coordination between the bladder and urethral sphincter) due to lack of the complex coordination of urine storage and voiding reflexes previously described. In this situation, the coordinated spinal→ bulbo→ spinal reflex is converted to an uncoordinated spinal→ spinal reflex. This is similar to the reflex present in the neonate prior to higher level brain development.

External Urethral Sphincter

The striated EUS is innervated by the pudendal nerve. The PMC stimulates GABA-ergic interneurons in the intermediomedial cell column (DGC), which subsequently inhibit the motoneurons located in Onuf nucleus. This leads to inhibition of the EUS via the pudendal nerve (18,19). Signals from the PMC also inhibit sympathetic outflow from the hypogastric nerve, leading to relaxation of the bladder neck, a process which facilitates emptying.

An Alternate Micturition Reflex

Projections from sensory neurons in the lumbosacrum only weakly communicate directly with PMC in humans, so there must be another pathway of communication from the bladder to the PMC (20). Projections between periaqueductal gray (PAG) in the caudal brainstem and the lumbosacrum appear to contain important sensory information from the bladder. This information then travels to the PMC so micturition can occur at an appropriate level of filling. Evidence for this includes observations that interruption of fibers between PAG and PMC result in a low capacity bladder, contracting at volumes of only a few milliliters (21). In addition, stimulation of PAG results in complete micturition (22).

Further support for the PAG's role in afferent input to the PMC is the interesting distinction between the sensory organization of humans and cats (higher mammals) and lower mammals (rodents). When rats are taken out of their cage, they urinate, but humans rarely urinate in stressful situations. An explanation may come from investigations revealing a more direct projection of sensory fibers in the lumbosacral cord to PMC in rats, perhaps reemphasizing the importance of the relay in humans between the lumbosacrum, PAG, and PMC (10,11).

Analyzing functional positron emission tomography (PET) and magnetic resonance imaging studies, Griffiths and Tadic (23) hypothesize a model (Fig. 17.10) in which secondary bladder afferents leaving the sacral and lumbar spinal cord synapse in the PAG and are relayed to the insula (right insula), forming the substrate for sensation. Insula representation may have slight right-sided predominance. The anterior cingulate gyrus (ACG) is responsible for monitoring, arousal, and efferent output to the PAG and PMC. The prefrontal cortex is involved in voluntary decision about voiding and generates efferent signals to control ACG and ultimately PMC. PMC provides motor output to cause voiding, as described earlier in this section (Fig. 17.11).

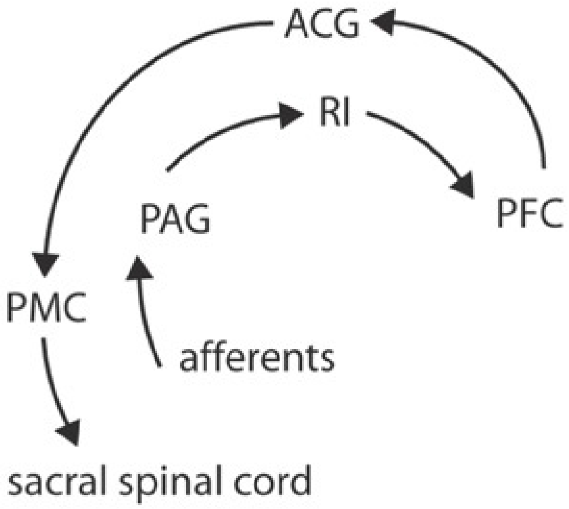


FIGURE 17.10 Griffiths and Tadic (23) hypothesis explaining a proposed periaqueductal gray (*PAG*) circuit and its connection to pontine micturition center (*PMC*). *ACG*, anterior cingulate gyrus; *PFC*, prefrontal cortex; *RI*, right insula.

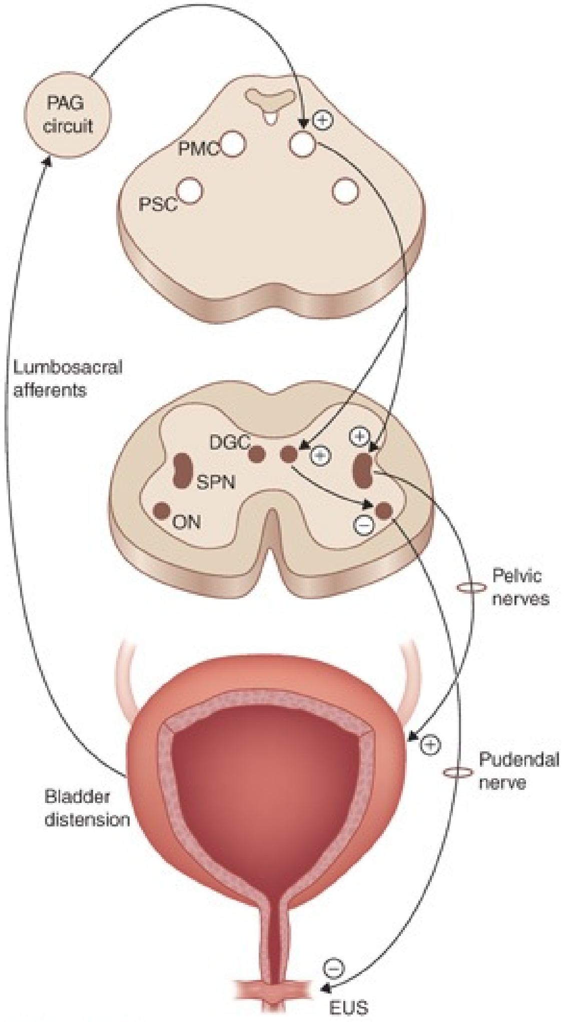


FIGURE 17.11 Micturition phase of bladder function. Micturition is stimulated by bladder distension. Sensory fibers carry information about bladder distension to the sacral spinal cord. Signals then ascend via pathways in the dorsal columns to the pontine micturition center (*PMC*). The *PMC* is the main center for coordination of lower urinary tract function. Information may pass through projections from the periaqueductal gray (*PAG*) (see Fig. 17.10) to the *PMC* (20). Motor responses then relay information back to the sacral parasympathetic nucleus (*SPN*), which ultimately triggers an excitatory stimulus for bladder contraction. Inhibitory signals to the dorsal grey commissure (*DGC*) leads to inhibition of Onuf nucleus (*ON*) and relaxation of the external urethral sphincter (*EUS*).

THE STORAGE REFLEX

Storage is facilitated by bladder afferent stimulation of Onuf nucleus, which increases tone of the EUS via the somatic pudendal nerve. A group of cells known as the pontine storage center (PSC) or L region is located more ventrally and laterally in the pons than the PMC. It projects to Onuf nucleus and is involved in the storage of urine during continence via a continuous excitatory effect during filling (11,15). Of note, the PMC and PSC are not interconnected at the level of the brainstem (24).

Simultaneously, the hypogastric (sympathetic) nerve, receiving input from pelvic afferents, inhibits detrusor muscle and bladder ganglia while stimulating the internal urethral sphincter (bladder neck), which has robust expression of alpha-1 receptors. As mentioned earlier, pharmacologic reduction in this bladder neck tone with alpha blockers is a mainstay for the treatment of benign prostatic hyperplasia as well as detrusor sphincter dyssynergia and other forms of voiding dysfunction (Fig. 17.12).

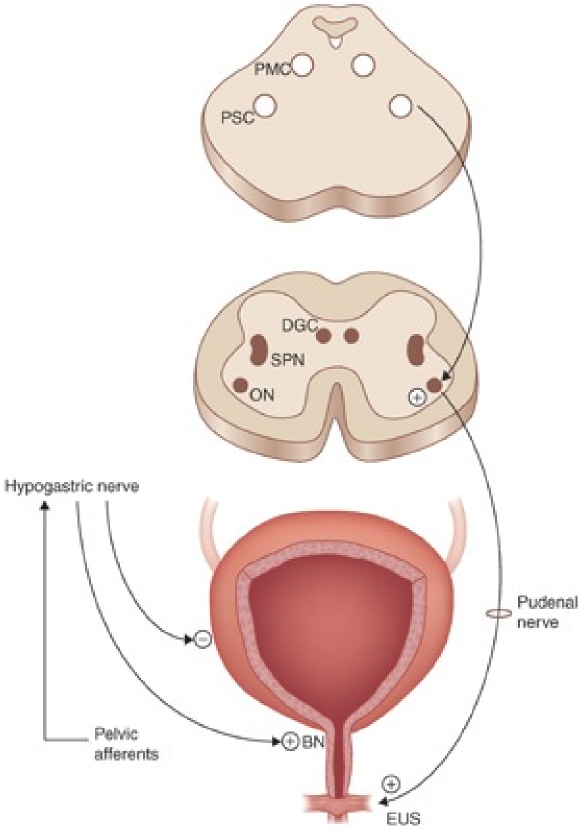


FIGURE 17.12 Storage phase of bladder function. Messages from the pontine storage center (*PSC*) stimulate Onuf nucleus (*ON*). Signals from *ON* travel via the pudendal nerve to stimulate the external urethral sphincter (*EUS*), resulting in continence. *DGC*, dorsal grey commissure; *PMC*, pontine micturition center; *SPN*, sacral parasympathetic nucleus.

ANATOMY OF SACRAL NEUROMODULATION

Sacral neuromodulation was largely pioneered by the work of Tanagho and Schmidt (25), whose studies focused on its use for the management of neurogenic bladder dysfunction, and by Shafik (26) whose studies revealed that stimulation of the EUS inhibits detrusor contraction.

It seems paradoxical that both detrusor overactivity and urinary retention can be improved with sacral neuromodulation, but there now exists decades of research to help explain why. Although the mechanism of action of sacral neuromodulation is not completely understood and is thought to be multifactorial, afferent pathways appear to play a crucial role as they modulate the activity in other neural pathways within the spinal cord and higher centers (27). One theory is that stimulating afferent pathways inhibits sacral interneuronal transmission, interrupting signals between the bladder and the pontine micturition center (28). This may explain why voluntary micturition is unaffected by sacral neuromodulation (29).

In studies of the latency of pelvic floor contraction during peripheral nerve evaluation, Fowler et al. (30) showed that the muscle response is reflexively mediated. These researchers measured latency of anal sphincter contraction in patients undergoing peripheral nerve evaluation of the S3 foramen, and based on longer latency between stimulation and contraction, they concluded that direct stimulation of the pudendal nerve could not be primarily involved. Instead, a more complex system than efferent stimulation must be involved. A study in patients with spinal cord injury concluded that although spinal pathways may be involved in the anal and pelvic floor response to S3 stimulation, supraspinal structures appear necessary for improvement in continence (31). Using stimulation of the dorsal penile nerve, a purely sensory nerve, the effect of pudendal afferent activity in sacral neuromodulation was demonstrated (32).

In separate studies using PET imaging during sacral neurostimulation, Blok et al. (33) and Dasgupta et al. (34) demonstrated that cortical and brainstem activity are affected by this therapy. Dasgupta's work suggests that brainstem activity can be improved with sacral neuromodulation, and this may help treat urinary retention in patients with external sphincter overactivity.

LYMPHATICS

The lymphatic drainage of the bladder is to the external iliac vein, the hypogastric nodes, or to the presacral promontory.

CONTIGUOUS STRUCTURES

In the male, the bladder joins the prostate and is anterior to the seminal vesicles and ampulla of the vas deferens. In the female, the bladder is in more direct contact with the pubococcygeus portion of the levator ani. Superiorly, the bladder is covered by peritoneum in both males and females. Posteriorly in females, the bladder is adjacent to the uterus and vagina. In males, the posterior bladder is adjacent to the seminal vesicles and rectum.

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CHAPTER 18 SIMPLE AND PARTIAL CYSTECTOMY

RYAN S. LEVEY AND JONATHAN C. PICARD

SIMPLE CYSTECTOMY

Simple cystectomy is performed in the setting of benign disease requiring urinary diversion or locally invasive nongenitourinary malignancy. Simple cystectomy involves removal of the bladder without resection of adjacent structures or performance of a formal lymph node dissection. The other pelvic organs are also left intact; to preserve sexual function, the prostate, seminal vesicles, and urethra are spared in the male patient and the uterus, anterior vagina, adnexa, and urethra are spared in the female patient. Removal of a defunctionalized bladder is often very beneficial and can prevent many complications.

Diagnosis

Preoperative evaluation should include a complete history and physical examination. Specifically, a thorough investigation into the etiology of the voiding dysfunction, radiation treatments, prior pelvic surgeries, and all other interventions leading up to this evaluation should be performed. Biopsy should be undertaken if primary bladder malignancy is a consideration. Preoperative imaging of the abdomen and bladder are usually helpful, and we prefer both noncontrasted and contrasted computerized tomography (CT) scans of the abdomen and pelvis with delayed images to allow for visualization of the ureters and any abdominal or pelvic pathology that would preclude the procedure.

Indications for Surgery

Urinary diversion is indicated for patients who have refractory conditions such as severe radiation or chemical cystitis, intractable bladder pain from interstitial cystitis, severe urinary incontinence, neurogenic bladder, extensive trauma, large fistula formation involving the bladder, or recurrent pyocystis. Simple cystectomy can also be undertaken for invasive nongenitourinary cancers that are not amenable to resection with partial cystectomy.

Previous attempts at urinary diversion without concomitant simple cystectomy have led to complications in 54% to 80% of patients (1–3). Complications include pyocystis, intractable hemorrhage, severe pain or spasms, and the sensation of incomplete emptying. In these patients, the salvage cystectomy rate ranges from 20% to 30% (1–3). One recent series purports much lower rates of complications. They describe only 7% of their 60 cases as having complications (three pelvic pains and one pyocystis) with none requiring salvage cystectomy (4). Given the lack of quality data, we recommend concomitant simple cystectomy when permanent urinary diversion is undertaken.

Additionally, the risk of developing urothelial cancer of the bladder is significantly increased in patients who have received previous pelvic irradiation (relative risk = 4.6) (3). Some authors have even cited a risk for malignant degeneration in the setting of chronic irritation such as interstitial cystitis (3).

Alternative Therapy

Radical cystoprostatectomy in men and radical cystectomy in women should be considered as alternatives to simple cystectomy in the setting of possible prostate cancer or urothelial carcinoma (UCC) and can be considered as alternatives in nongenitourinary malignancies that are locally invasive into the bladder or in many benign diseases of the bladder. In the majority of patients, continued observation, hyperbaric oxygen, analgesic prescription, and other symptomatic treatments are the initial options, with simple cystectomy only being offered as a final intervention in patients with refractory nonmalignant disease.

In patients with nongenitourinary malignancies that are locally invasive into the bladder, simple cystectomy can be considered if the resection can be accomplished with negative margins. Laparoscopic and robotic-assisted laparoscopic techniques are also being refined and are certainly an option for appropriately trained surgeons, despite the fact that these procedures are often difficult due to the challenges of previously irradiated fields, previous surgery, and chronic infection or inflammation. Further, one group has developed a novel operative technique where the bladder is bivalved and resected, leaving a bladder base including the trigone and bladder neck. The remaining mucosa is then resected and fulgurated, with a small rim of detrusor muscle preserved (5). This technique may become another option with further validation over time.

Surgical Technique

Simple cystectomy can be undertaken extraperitoneally to avoid abdominal adhesions due to multiple previous surgeries or radiation; however, we prefer an intraperitoneal approach as these patients also frequently require concomitant urinary diversion. Antithrombotic medication, pneumatic compression cuffs, or compression stockings should be strongly considered prior to induction of anesthesia. The patient is positioned supine on the operating room table with the anterior superior iliac spines positioned over the inferior portion of the table break or kidney rest. The table is flexed to facilitate exposure, and the bed is slightly tilted in the Trendelenburg position until the abdomen is parallel to the floor. When urethrectomy is planned, a modified lithotomy position provides improved exposure to the perineum. The abdomen and pelvis are then prepped with an antimicrobial solution extending from the costal margin superiorly to the perineum, including the penis in men and the vagina in women. The patient is draped, and a Foley catheter is inserted following sterile procedures. The bladder is allowed to drain completely. Filling the bladder with 150 to 200 mL of sterile water may facilitate the dissection.

An intravenous antibiotic agent should be administered less than 1 hour prior to skin incision. A lower midline incision extending from the umbilicus to the pubic symphysis is made. The anterior rectus fascia should be opened sharply, and the rectus abdominis muscles in the midline should then be separated to facilitate entry into the space of Retzius.

The extraperitoneal space lateral to the bladder should be bluntly developed by extending the dissection from the bladder neck cranially to the dome of the bladder. In benign conditions, incising the anterior bladder wall may facilitate the dissection. The peritoneum should be incised lateral to the bladder in a posterior direction. The ureters can often be identified as the peritoneum is divided and reflected. They should then be dissected from their surrounding attachments, with care being taken to maintain a sufficient amount of periureteral tissue. The ureteral dissection should be continued proximally and distally. In women, care must be taken to avoid the uterine artery during the distal ureteral dissection. When the superior vesical arteries are encountered crossing anterior to the distal ureters, they should be ligated with 2-0 silk ties and divided (Fig. 18.1) to allow for improved exposure of the distal ureter and maximization of the ureteral length. The ureters are then clipped close to their insertion into the bladder and divided sharply. They can be packed away to prevent injury during the remainder of the bladder dissection.

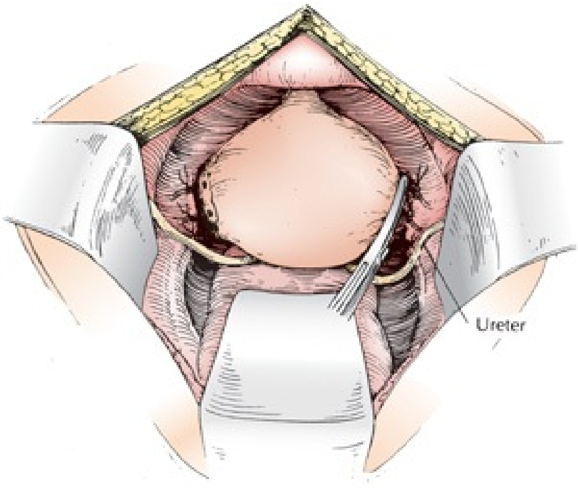

FIGURE 18.1 The vesical pedicles are clipped and divided.

In male patients, we begin our posterior dissection several centimeters anterior to the peritoneal reflection and enter the plane between the bladder (anterior) and the vasa deferentia and seminal vesicles (posterior) (Fig. 18.2). This dissection is continued to the prostatovesical junction using a combination of blunt and sharp dissection. Attention is then returned to the anterior dissection of the prostatovesical junction. The veins overlying the prostate and bladder can be ligated with 3-0 silk suture and divided. The bladder is then drained and the Foley catheter removed. Bovie cautery is used to transect the bladder in an anterolateral direction, and the posterior bladder wall is then divided to expose the previously exposed vasa deferentia and seminal vesicles (Fig. 18.3). The lateral vascular pedicles should be readily visible and can be ligated with 2-0 silk ties and divided. Instead of suture ligation, these pedicles can also be divided using an electrothermal bipolar sealing system such as a LigaSure device or using a linear cutting surgical stapler with the appropriate staple load. At this point, the bladder should be free and can be removed. The urethra is oversewn with 3-0 Vicryl suture, and the prostatic surgical capsule is oversewn with 0 Vicryl suture (Fig. 18.4). If significant prostatic hyperplasia prevents adequate closure of the capsule, a simple prostatectomy should be considered followed by closure of the prostatic surgical capsule as previously described.

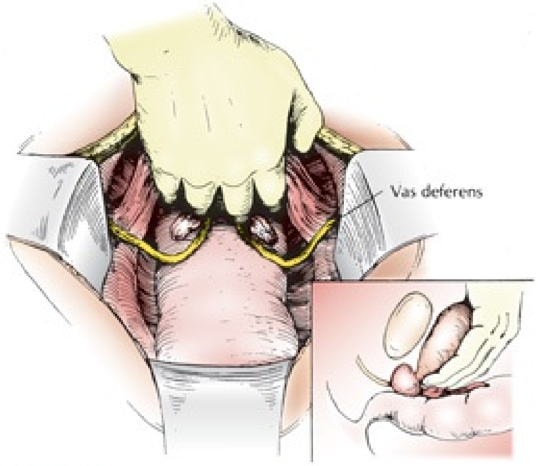

FIGURE 18.2 The plane between the bladder (anterior) and the vasa deferentia and seminal vesicles (posterior) is dissected.

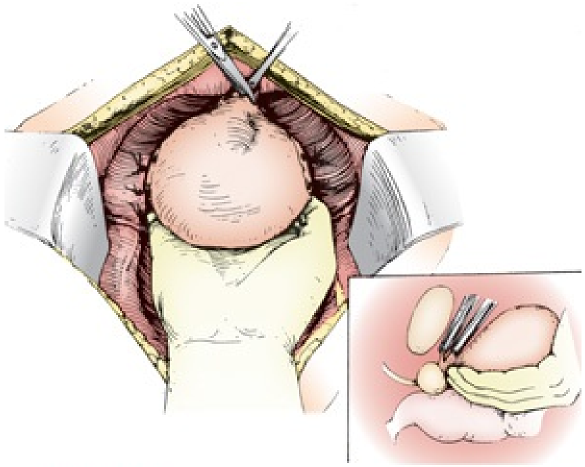

FIGURE 18.3 The bladder neck is incised anteriorly.

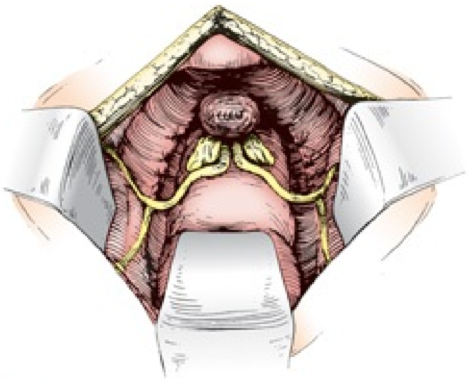

FIGURE 18.4 The bladder is removed. The urethra is oversewn. The prostatic surgical capsule is oversewn.

In female patients, the posterior dissection begins anterior to the peritoneal reflection. The plane between the bladder and the anterior vaginal wall is entered and is developed with sharp and blunt dissection. An intravaginal sponge stick is beneficial for traction and identification of the proper planes. During this dissection, the lateral pedicles are ligated with 2-0 silk ties and divided as they are encountered. Upon reaching the bladder neck, the Foley catheter is removed and Bovie cautery is used to transect the urethra. The urethral stump is then oversewn with 3-0 Vicryl sutures. Some authors advocate complete urethrectomy including the meatus in patients who have cystectomy performed for interstitial cystitis.

After the cystectomy is complete, the wound is copiously irrigated with sterile water. A closed drainage system, such as a Jackson-Pratt or Blake drain, is almost universally placed in the pelvis because this procedure is frequently performed in the setting of chronic inflammation or infection. Attention is next turned to creation of the urinary diversion of the surgeon's choice.

The abdominal wall is closed beginning with the rectus fascia. The edges of the rectus fascia are reapproximated using a 0 looped polydioxanone suture (PDS) in a running fashion. The wound is copiously irrigated with sterile water. If there is a large amount of subcutaneous tissue, the Scarpa fascia can be reapproximated using a 3-0 or 4-0 Vicryl suture to minimize the dead space. The skin is closed with a subcuticular 4-0 Monocryl suture or skin staples.

Outcomes

Surgical outcomes are generally very good, although the available literature is limited. One series suggested a mortality rate of 0% with no morbidities directly attributable to the cystectomy itself (2). Likely, the most important aspect of simple cystectomy is the morbidity that is prevented by removing the bladder at the time of urinary diversion. In patients not undergoing concomitant cystectomy with urinary diversion, major complications and hospitalization occur in >50% with >20% requiring a salvage operation, although one recent case series reports substantially lower complication rates of 7% and 0%, respectively (1–4).

Complications

For both partial cystectomy and simple cystectomy, the usual risks associated with urologic surgeries exist, including pulmonary embolus, myocardial infarction, bleeding that requires transfusion, ileus, and wound complications such as infections or seromas. The majority of complications are related to the urinary diversion rather than the simple cystectomy itself. Although there are no data directly related to simple cystectomy, the overall complication rate of partial cystectomy is classically reported as 11% to 29%, and the complication rate for simple cystectomy is likely similar.

PARTIAL CYSTECTOMY

Partial cystectomy is a full-thickness excision of abnormal bladder and a margin of adjacent normal bladder with the goal of preserving adequate bladder function and capacity. Traditionally, this surgery has been utilized in the management of localized urachal adenocarcinoma, an isolated UCC associated with a diverticulum, localized unifocal UCC in favorable locations, or in patients who are unable or unwilling to undergo radical cystectomy. This procedure offers the advantages of full-thickness resection of the diseased bladder in conjunction with a pelvic lymph node dissection for pathologic review while allowing for conservation of the native bladder and preservation of potency and continence.

Diagnosis

Preoperative evaluation before undertaking a partial cystectomy should include a thorough history and physical examination with a focus on prior pelvic surgeries or procedures and previous bladder pathology. Cystoscopy should be performed with biopsy of the lesion for histologic diagnosis. Additional mapping biopsies should be performed to confirm unifocality of the disease and to exclude carcinoma in situ. Both noncontrasted and contrasted CT scans of the abdomen and pelvis with delayed images of the urinary collecting system should be performed to assist with staging. Findings such as upper-urinary-tract involvement with disease, metastatic lesions, enlarged lymph nodes >1 cm, or other pelvic pathology may preclude utilizing this procedure.

Indications for Surgery

Partial cystectomy has emerged as the treatment of choice for localized urachal adenocarcinoma. The urachus is an embryologic remnant that persists in approximately 30% of the population and is capable of malignant transformation. In this setting, open partial cystectomy or laparoscopic partial cystectomy should be undertaken with en bloc resection of the involved bladder with a 2-cm margin of normal tissue, umbilicus, peritoneum, and posterior rectus fascia with concomitant pelvic lymphadenectomy. The 5-year survival rate in this setting is approximately 88% (6).

In the setting of UCC, partial cystectomy is indicated only in highly selected patients with limited disease, patients who are not candidates for radical cystectomy due to comorbid conditions, and patients who refuse radical cystectomy. Selection criteria should include no history of previous urothelial cancer, localized disease that is unifocal in nature without coexisting carcinoma in situ (CIS), and disease that is present in an area of the bladder that is amenable to complete resection with a negative margin. Patients must have a bladder volume that allows for resection of the diseased site with an adjacent 2-cm margin while still maintaining adequate functional capacity with normal compliance. We do not recommend partial cystectomy if resection of the bladder neck is required.

A special circumstance exists in the patient who presents with a bladder diverticulum containing a UCC. Because of the thin, amuscular walls of the diverticulum, these lesions are often at increased risk of higher stage disease. Additionally, attempted transurethral resection of a UCC within a diverticulum has a higher risk of perforation. For these reasons, this pathology is particularly amenable to partial cystectomy.

Other indications for partial cystectomy include resection of nonurologic cancers in the bladder, including pheochromocytoma, paraganglioma, rhabdomyosarcoma, osteosarcoma, lymphoma, and adjacent tumors that are locally invasive into the bladder, such as invasive colorectal cancer. Partial cystectomy may also be indicated in benign diseases such as a symptomatic diverticulum.

Alternative Therapy

Any malignant bladder tumor that is removable by partial cystectomy can also be removed by radical cystectomy, although morbidity may be increased. There have also been many advances in endoscopic tools and techniques. Some tumors may now be approached endoscopically via an aggressive transurethral approach or laparoscopically with a simple cystectomy. In regard to urothelial cancer, intravesical agents—including chemotherapy and bacille Calmette-Guérin (BCG) immunotherapeutic agents—have also been utilized to manage some of these patients. Radiotherapy and chemotherapy, alone or in combination, are also alternatives to cystectomy in the setting of muscle-invasive UCC. For many benign indications, simple cystectomy is an alternative.

Surgical Technique

Antithrombotic medication, pneumatic compression cuffs, or compression stockings should be strongly considered prior to induction of anesthesia. The patient is positioned supine on the operating room table with the anterior superior iliac spines positioned over the inferior portion of the table break or kidney rest. The table is flexed to facilitate exposure, and the bed is tilted slightly in the Trendelenburg position until the abdomen is parallel to the floor. The abdomen and pelvis are then prepped with an antibiotic solution extending from the costal margin superiorly to the perineum, including the penis in men and the vagina in women. After the patient is draped, a Foley catheter is inserted following sterile procedures. The bladder is then allowed to drain completely. At this point, filling the bladder with 150 to 200 mL of sterile water may facilitate the dissection.

An intravenous antibiotic agent should be administered prior to skin incision. A lower midline incision from just below the umbilicus (around and including the umbilicus if for urachal adenocarcinoma) to the pubic symphysis is made. The anterior rectus fascia should be opened sharply, followed by separation of the rectus abdominis muscles in the midline to facilitate entry into the space of Retzius.

Using blunt dissection, the tissues are dissected down to the level of the bladder dome at the reflection of the peritoneum. For dome or anterior tumors, it is possible to remain extraperitoneal; however, for posterior tumors, an intraperitoneal approach is recommended.

Extraperitoneal Partial Cystectomy

The extraperitoneal space lateral to the bladder is developed bluntly, extending from the bladder neck cranially to the dome of the bladder. The anterior aspect of the bladder is exposed to the peritoneal reflection, which is mobilized where it is readily separable. A bilateral pelvic lymph node dissection is undertaken using the bifurcation of the common iliac artery as the cranial limit, the pubic symphysis as the caudal limit, the genitofemoral nerve as the lateral limit, and the bladder as the medial limit of the dissection. All nodal tissue is dissected and sent for pathologic review. Prudent use of silk ties or titanium clips, especially at the cranial and caudal limits of the dissection, may limit the risk of lymphocele formation.

The bladder is freed from its surrounding attachments, with care being taken to preserve the perivesical fat overlying the region of interest. Blunt dissection is the primary approach, along with judicious use of cautery to minimize the risk to adjacent peritoneal contents. The superior vesical pedicle may be divided to provide adequate exposure of the resection site. This division may be performed with a LigaSure (Valleylab) device or in the traditional manner with hemostats and 2-0 silk ties. Once the bladder is freed, the area of the tumor should be localized with preoperative or intraoperative cystoscopy.

Several sutures are placed some distance from the known pathology. At this point, the bladder should be drained completely to prevent urinary spillage. The free wound edges can be covered with laparotomy pads moistened with sterile water. The bladder is incised using Bovie cautery in an area at least 2 cm away from the expected lesion. The incision is extended to allow for visualization of the pathology. The tumor is excised using Bovie cautery with a 2-cm margin on all sides, and the specimen is removed en bloc with the overlying perivesical fat and any adherent peritoneum (Fig. 18.5).

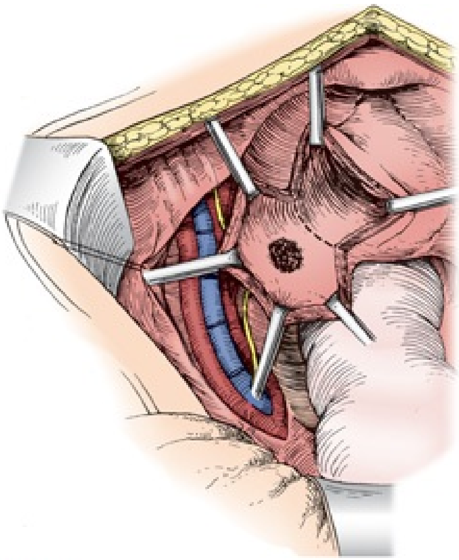

FIGURE 18.5 A 2-cm margin of normal bladder is taken around the tumor.

In general, we do not recommend this operation when ureteral reimplantation is necessary. However, in the event that a ureteral reimplantation is needed to complete the partial cystectomy, the ureter should be divided and the proximal ureter reimplanted into the bladder via the Politano-Leadbetter technique or the simple nipple reimplantation technique. A 4-0 Vicryl suture should be used for performing an interrupted ureterovesical anastomosis over a ureteral stent.

Once excision of the tumor is completed and adequate hemostasis is ensured, the bladder can be closed in two layers utilizing a running 4-0 Vicryl suture on the urothelium and a running, locking 2-0 Vicryl suture to close the muscularis layer (Fig. 18.6). Special consideration should be given to the apices of the closure because these are the most frequent sites of urinary leakage after closure. A suprapubic cystostomy is contraindicated in the setting of UCC; however, it can be considered for other pathologies. The wound is copiously irrigated with warm sterile water. A closed drainage system, such as a Jackson-Pratt drain or Blake drain, can be placed in a dependent position within the area of dissection. To minimize fistula formation, this drain should not be placed directly adjacent to the cystotomy closure. The anterior rectus fascia is reapproximated using a 0 looped PDS in a running fashion, and the wound is copiously irrigated with sterile water. The skin is closed with a subcuticular 4-0 Monocryl suture.

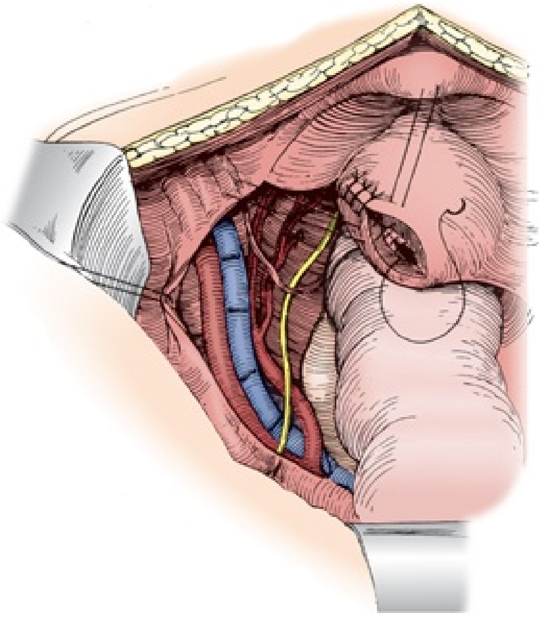

FIGURE 18.6 The bladder is closed in two layers.

The drain is removed on postoperative day 2 or 3 or when the output is <30 mL per shift. The catheter is removed on postoperative day 7. If complete bladder healing is a concern, a low-pressure cystogram can be performed.

Intraperitoneal Partial Cystectomy

Partial cystectomy through an intraperitoneal approach is often necessary with tumors on the posterior bladder wall. The extraperitoneal space lateral to the bladder is bluntly developed by extending the dissection from the bladder neck cranially to the dome of the bladder. The posterior rectus sheath and peritoneum just inferior and lateral to the umbilicus are divided sharply to enter the peritoneal cavity. The bowel is retracted into the upper abdomen using a retraction system such as the Bookwalter or Omni-Tract system. Trendelenburg can be steepened to assist in packing the bowel away. The peritoneum is incised over the iliac vessels, and the node dissection is undertaken using the same landmarks as described in the extraperitoneal approach. The procedure follows the steps previously described; the posterior aspect of the bladder is freed to allow adequate exposure, and the superior vesical artery is divided as needed. The lesion is located, and stay sutures are placed some distance away from the site of disease. After the bladder dissection is complete, the bladder is drained. The bladder is then incised, and the tumor is excised with a 2-cm margin followed by bladder closure and management of the Foley catheter and drains as previously described in the extraperitoneal approach.

Outcomes

In modern partial cystectomy series for the management of UCC, outcomes are good, with a 5-year overall survival rate of 64% to 70% and a 5-year disease-specific survival rate of 74% to 84% (7–9). However, UCC is well known for its high recurrence rates. In partial cystectomy series, recurrence rates range from 28% to 49%, with an approximate recurrence rate of 20% to 25% in locally advanced or metastatic disease. Because of this high recurrence rate, most authors agree that lifelong cystoscopy and repeat abdominal and pelvic imaging should be performed in these patients. Disease recurrence requires aggressive treatment similar to treatment for recurrence with other treatment modalities, including repeat transurethral resection, use of intravesical agents, chemotherapy and/or radiation protocols, and radical cystectomy with urinary diversion when indicated.

The success of partial cystectomy for urachal adenocarcinoma with en bloc resection of the urachus, umbilicus, and surrounding soft tissues with negative margins has resulted in an 88% 5-year disease-free survival rate (6). Local recurrence rates are approximately 18% with aggressive resection. Furthermore, a review of multiple small surgical series would suggest no survival benefit to radical cystectomy over extended partial cystectomy with en bloc resection, but a randomized trial has not been done.

Complications

For both partial cystectomy and simple cystectomy, the usual risks associated with urologic surgeries exist, including pulmonary embolus, myocardial infarction, bleeding that requires transfusion, ileus, and wound complications such as infections or seromas. Other more specific complications include reduction of bladder capacity, urinary leakage, fistula formation, and lymphocele formation. Recurrence is a concern and is discussed previously. The overall complication rate of partial cystectomy is classically reported as 11% to 29%. One retrospective review of 10,780 cases of partial cystectomy for bladder cancer reported a 15.8% complication rate and 1.8% mortality rate (10).

Of special consideration is the reduction in functional capacity during partial cystectomy. There are no good data to determine how much bladder capacity can be removed while still allowing good function. Preoperative urodynamic testing may be of some benefit in accurately assessing preoperative bladder capacity.

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CHAPTER 19 RADICAL CYSTECTOMY IN MEN

MOHAMED A. GHONEIM AND AHMED M. HARRAZ

Although more complex urinary diversions are increasingly employed, contemporary cystectomy is associated with very low mortality. Furthermore, the advent of nerve-sparing cystectomy and orthotopic bladder substitution has significantly reduced functional losses and provided many patients with good locoregional control as well as a good quality of life. The technique, herein described, is based on cumulative experience of more than 30 years during which more than 2,000 cystectomies were carried out at the Department of Urology, Mansoura University, Egypt (1).

DIAGNOSIS

The diagnosis of transitional-cell carcinoma is generally made by transurethral resection of the tumor in the bladder. Once the diagnosis has been established, it is important to know the pathologic stage, particularly if the tumor invades the muscularis propria. Invasion of the muscularis mucosa is an important distinguishing factor and is not considered as constituting a muscle-invasive tumor. The clinical staging of transitional-cell carcinoma can generally be performed by abdominal and pelvic computerized tomographic (CT) scans and chest imaging. Occasionally, radionuclide bone scans are indicated if there is either symptomatic bone pain, abnormalities on the CT scan, or the patient has either an elevated serum calcium or alkaline phosphatase.

INDICATIONS FOR RADICAL CYSTECTOMY IN MEN

The major indication for cystectomy in men is carcinoma of the bladder. In general, the operation is carried out for the following:

1. Patients with superficial tumors in whom endoscopic control has failed in spite of adjuvant intravesical chemo- and/or immunotherapy. Although these measures have proven effective in the management of such cases (<T1), an important minority fail. High tumor grade, multifocal lesions, diffuse carcinoma in situ, and involvement of the prostatic urethra were all reported as high-risk factors.
2. Infiltrating tumor without evidence of distant metastasis. These include tumors infiltrating the muscle layers (P_2, P_{3a}) or the perivesical fat short of the pelvic wall (P_{3b}). Infiltration of adjacent organs (P_4) or involvement of the regional lymph nodes is not considered as a contraindication for the procedure.

The radical operation in men includes the removal of the bladder, its peritoneal covering, the perivesical fat, the lower ureters, the prostate, the seminal vesicles, and the vasa deferentia. In the standard procedure, as much as possible of the membranous urethra is also removed, and total urethrectomy is carried out only if there is involvement of the prostatic urethra (2).

ALTERNATIVE THERAPY

Alternatives to radical cystectomy include local therapy, partial cystectomy, intravenous chemotherapy, radiation therapy, or a combination of chemotherapy and radiation therapy. Local therapy in invasive disease generally results in progression of the disease and death of the patient within 5 years. Systemic chemotherapy or radiation therapy is associated with a 25% 5-year survival, although the combination of the two modalities can improve 5-year overall survival probability up to 48% (3).

SURGICAL TECHNIQUE

Preparation of the Patient

In view of the extent of surgery, the length of the operative time, and often advanced patient age, a thorough medical evaluation and anesthetic consultation are required.

Bowel preparation is necessary before surgery. If it is planned to use the small bowel, oral neomycin and a low-residue diet are all that are needed. More rigorous preparation with full bowel prep is required if the colon is utilized.

Patients with histories of thromboembolic disease or varicose veins should receive a prophylactic dose of heparin (5,000 U subcutaneously) the night before the operation and every 12 hours thereafter until ambulation. A parenteral broad-spectrum antibiotic is given just before induction of anesthesia and continued postoperatively for 3 days. The region extending from the midchest to the midthigh should be cleaned and prepared on the night before surgery.

Anesthesia and Instrumentation

Full relaxation of the abdominal muscles by an appropriate anesthetic is necessary throughout the entire procedure. Hypotensive anesthesia would provide an additional advantage and would reduce blood loss.

The choice of instruments depends mainly on the surgeon’s preference. Standard retractors of various sizes and curves as well as long curved and angled scissors are needed. Long curved clamps should also be available.

Position and Initial Exposure

The patient is put in the supine position with a Trendelenburg tilt. Slight bending of the knees would further help in the relaxation of the abdominal muscles, facilitate retraction, and provide a wider exposure. If a total urethrectomy is planned, the patient is put in a slight lithotomy position for access to the perineum.

The surgical area to be sterilized and draped extends from the lower chest down to the root of the penis. A self-retaining catheter is introduced into the bladder and kept indwelling for its evacuation throughout the procedure.

A long, vertical, right paramedian incision extending from the symphysis pubis inferiorly to a point halfway between the umbilicus and xiphoid process of the sternum superiorly is generally employed. Alternatively, a midline incision encircling the umbilicus can also be utilized. For obese patients, a lower abdominal muscle-cutting transverse incision is preferred. Under such circumstances, it provides a wide and direct exposure of the pelvis.

Initially, the abdominal and pelvic cavities are explored. The growth is palpated, its degree of mobility determined, and its relation to the adjacent structures assessed. The endopelvic and aortic lymph nodes are palpated and frozen sections are taken if necessary. The general peritoneal cavity, omentum, intestinal tract, kidney, spleen, and liver are thoroughly examined. If the decision is to proceed with the radical operation, the intestines are packed out of the pelvis, and the retropubic space is opened by blunt dissection. Any small bleeders are coagulated. This dissection is extended inferiorly and laterally until the ventral surface of the bladder and prostate are exposed. The peritoneal incision is extended inferiorly on either side of the urachal remnant. The urachal remnant is dissected off its attachment with the umbilicus and clamped. In this manner, a triangular peritoneal flap with its apex pointing superiorly is raised and will be removed later en bloc with the bladder.

Lymphadenectomy

The peritoneal incision, on either side, is extended posterolaterally along the lateral border of the external iliac and common iliac vessels up to the aortic bifurcation. The vas deferens is identified and ligated near the internal ring. The fascia on the iliopsoas is incised and reflected medially. The triangle of Marseille is exposed by retracting the common and external iliac arteries medially and dissecting the space between these vessels and the medial border of the psoas muscle (4). Dissection of the fibrolymphatic tissues in this space will expose the obturator nerve as it emerges from the medial border of the psoas muscle (Fig. 19.1). The fibrofascial sheath covering the distal half of the common iliac and the external iliac vessels is then opened and stripped medially to remove the perivascular lymphatics and lymph nodes (Fig. 19.2A). The vessels are gently retracted laterally and immediately below and medial to the cleaned external iliac vein, and the obturator space is entered (Fig. 19.2B). By working right on the psoas and obturator muscles, one can strip all the pelvic fascia medially without difficulty. The obturator neurovascular bundle is included in the stripped mass. The obturator nerve is identified and separated from its vessels, which are ligated and divided as they leave the pelvis through the obturator foramen. Dissection is facilitated and the operating time reduced by the use of electrocoagulation to control lymphatic and small blood vessels throughout the lymphadenectomy. The fibrolymphatic mass is now reflected medially, and the internal iliac artery and its branches are identified (Fig. 19.2C), and its anterior division is divided and ligated. This completes the lateral dissection (Fig. 19.3A and B).

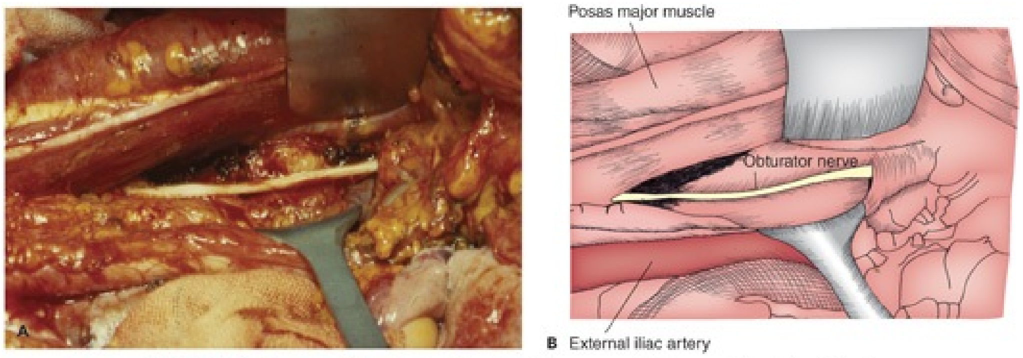

FIGURE 19.1 Dissection of the triangle of Marseille. The psoas muscle is retracted laterally and the iliac vessels medially. The obturator nerve is exposed in the floor of the triangle as it emerges from the medial border of the Psoas muscle. A: Operative photograph. B: Explanatory diagram.

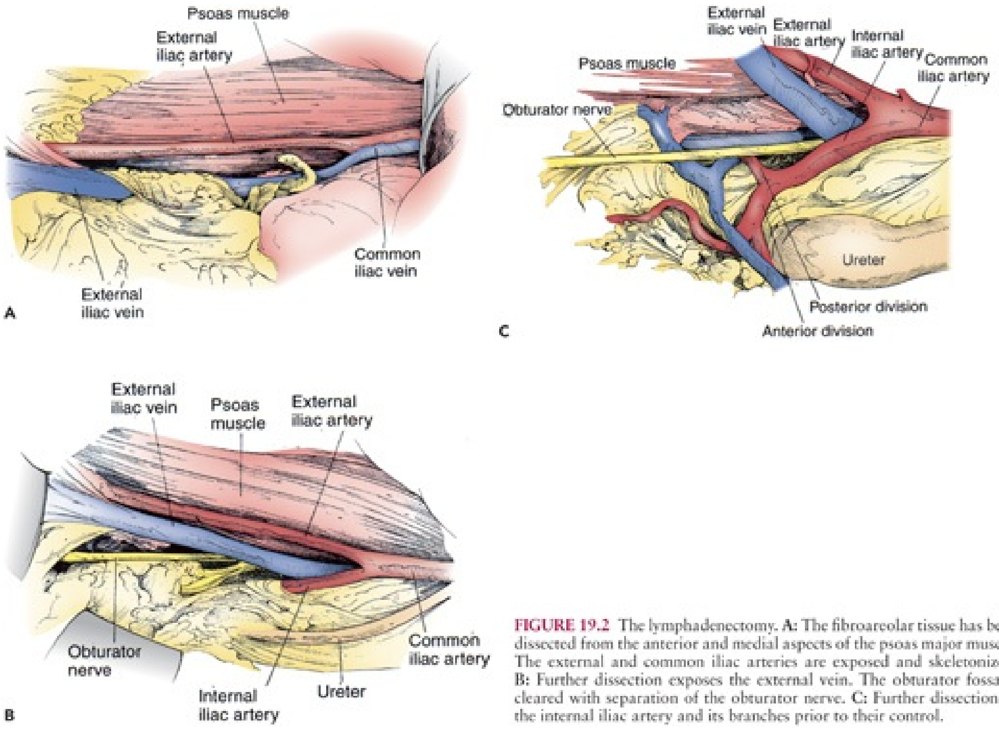

FIGURE 19.2 The lymphadenectomy. **A:** The fibroareolar tissue has been dissected from the anterior and medial aspects of the psoas major muscle. The external and common iliac arteries are exposed and skeletonized. **B:** Further dissection exposes the external vein. The obturator fossa is cleared with separation of the obturator nerve. **C:** Further dissection of the internal iliac artery and its branches prior to their control.

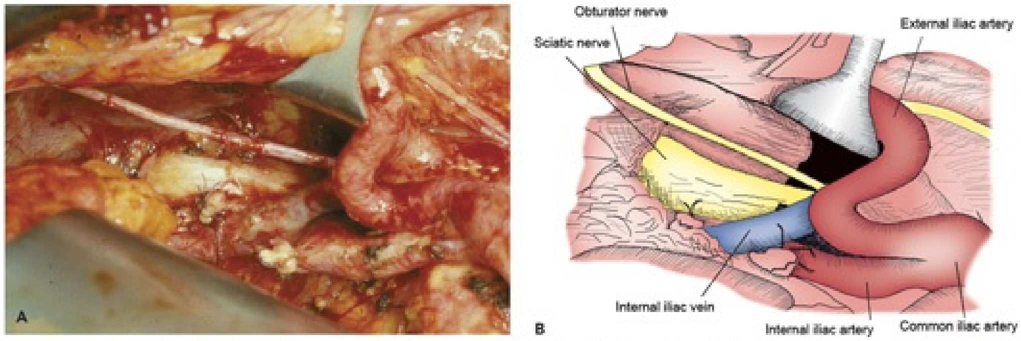

FIGURE 19.3 The lateral dissection is completed. The anterior division of internal iliac artery is divided with control of its parietal branches. **A:** Operative photograph. **B:** Explanatory diagram.

The ureter is identified where it crosses the common iliac bifurcation, dissected free for 3 to 4 cm, divided, and its distal end ligated. While traction is applied on the ligated ureteric stump of the ureter, finger dissection along its posteromedial border opens the space of Denonvilliers laterally. The step greatly helps in the definition of the plane between the bladder and rectum, which will be required at a later stage in the operation.

Cystoprostatectomy

The endopelvic fascia on either side on the prostate is then opened by the tip of a blunt pair of scissors (Fig. 19.4). The optimal site for the creation of this opening is a white line marking the fusion of the parietal fascia lining the pelvic surface of the levator ani with the visceral fascia covering the lateral surface of the prostate. A right-angle clamp is used to lift the fascia from the underlying venous plexus, and it is further incised medially until the prostatic ligaments are reached. By blunt dissection, this plane is further developed posteriorly on either side of the prostate. Further anterior dissection is deferred to the final stages of the procedure to minimize the possibility of sudden blood losses from inadvertent injury of the prostatic venous plexus.

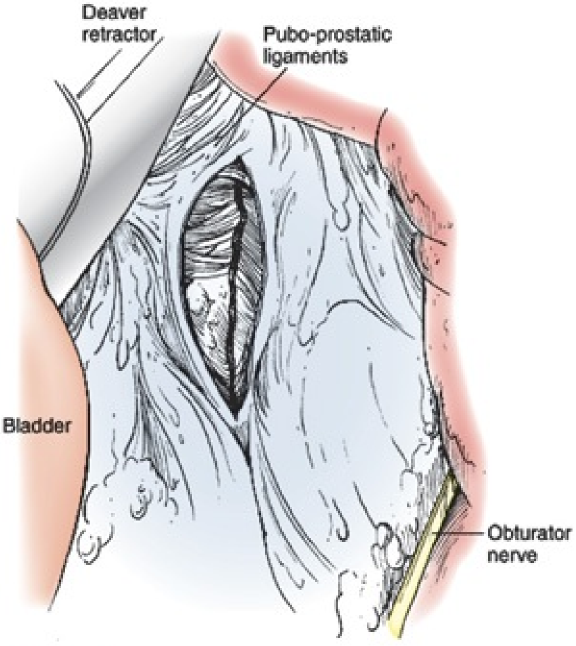

FIGURE 19.4 The bladder and prostate are retracted medially by a Deaver retractor. The reflection of the endopelvic fascia from the ventral surface of the levator ani to the prostate is opened. Blunt dissection would further develop this space and expose the lateral surface of the prostate.

The specimen is now lifted ventrally by applying traction on the median umbilical ligament (urachus). The two planes developed along the posteromedial borders of the ureter on either side are easily joined together by blunt dissection. As a result, the peritoneal reflection from the anterior surface of the rectum to the back of the bladder could be stretched and safely incised by diathermy. The potential space between the rectum posteriorly and the bladder, seminal vesicles, and prostate anteriorly is opened by blunt dissection (Fig. 19.5). As the prostatic apex is reached, this space becomes obliterated as a result of fusion of the two layers of the fascia of Denonvilliers. This cul-de-sac is opened by the blunt tip of long angled scissors. Once this is completed, the tip of the surgeon’s forefinger would readily feel the apex of the prostate as well as the catheter in the urethra in the midline. Alternatively, if it is directed laterally, it will appear through the previously created openings on either side of the prostate (Fig. 19.6).

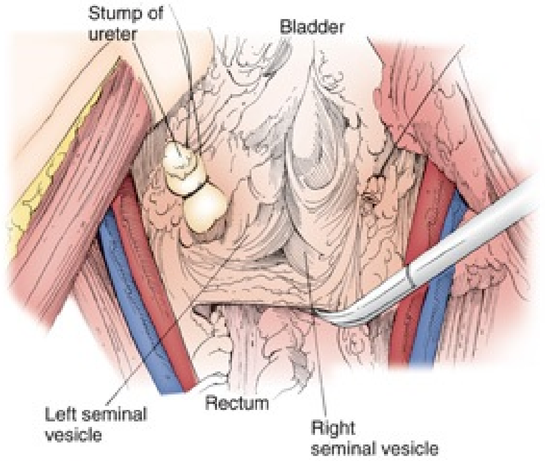

FIGURE 19.5 The peritoneum of the floor of Douglas pouch is incised by diathermy. The space between the rectum posteriorly and the bladder and seminal vesicles anteriorly is dissected and opened.

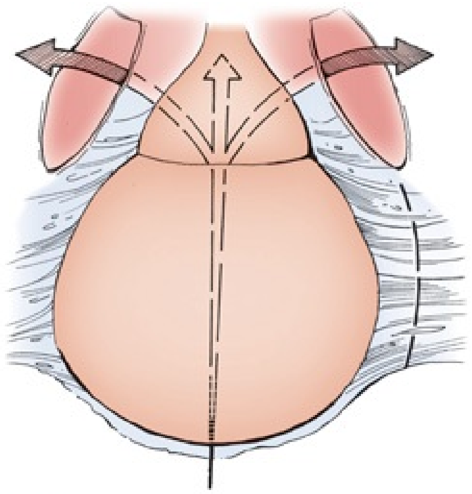

FIGURE 19.6 The cul-de-sac formed by the fusion of the two layers of the fascia of Denonvilliers is opened by the tip of a blunt pair of long scissors. Thereafter, the tip of the surgeon's forefinger would feel the apex of the prostate and the catheter in the urethra. If the forefinger is directed laterally, it would appear through the previously created openings on either side of the prostate. Thus, a thick, wide, fascial band is defined (the vesicoprostatic pelvic fascia). It is divided piecemeal between clamps (*arrows* and *interrupted line*).

In this manner, a thick and wide fascial band is created on either side, connecting the bladder, vesicles, and prostate anteriorly with the pararectal fascia posteriorly (the vesicoprostatopelvic fascia). This is divided piecemeal between clamps, which are underrun by 2-0 polyglactin sutures.

The bladder is now free laterally and posteriorly, and the mass is left to drop in the pelvis. Attention is now focused on the anterior and final phase of the procedure. The puboprostatic ligaments are identified by applying traction on the prostate in a cephalad and posterior direction. These ligaments are carefully severed at the point of their insertion in the pubic bone. The prostatic venous plexus is controlled by one or two sutures of 3-0 polyglactin acid placed near the prostatic apex. A transverse incision is made proximal to these sutures with a long scalpel and extended with sharp dissection by scissors, exposing the urethra, within which the catheter can be palpated (Fig. 19.7). The catheter is then withdrawn; the urethra is clamped and transected; the distal end is ligated; and the specimen is removed. Final hemostasis is achieved by inserting deep 2-0 polyglactin sutures between the edges of the levator ani muscles on either side (Fig. 19.8). No attempt is made to reperitonealize the pelvis. Two tube drains are placed in the pelvic cavity and brought out through separate incisions in the abdominal wall. The wound is closed in layers with particular attention for careful closure of the anterior rectus sheath. This is closed with interrupted sutures of nylon with the knots tied to the inside.

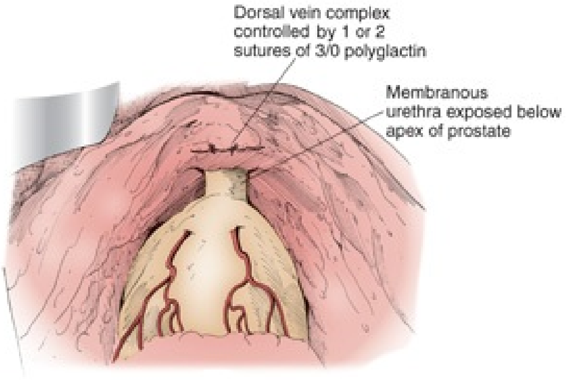
Dorsal vein complex controlled by 1 or 2 sutures of 3/0 polyglactin
Membranous urethra exposed below apex of prostate

FIGURE 19.7 The puboprostatic ligament is incised and the prostatic venous complex controlled. The membranous urethra is thus exposed.

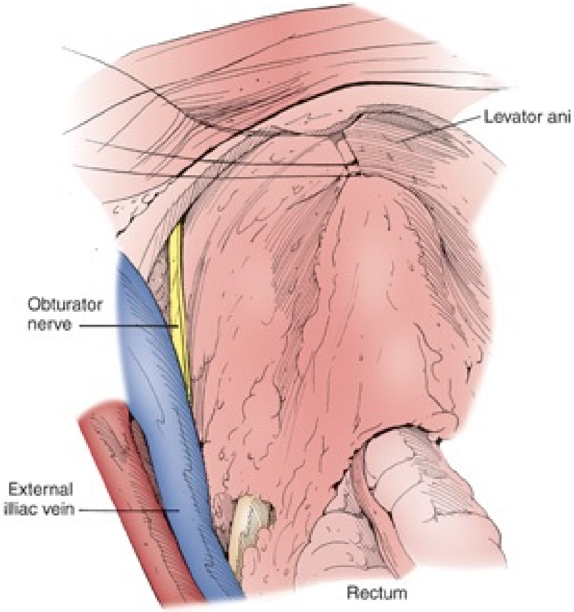

FIGURE 19.8 The specimen is removed. Final hemostasis is achieved by two to three interrupted sutures of 3-0 polyglactin between the two medial borders of levator ani muscles.

Variations on a Theme

Extended Lymphadenectomy

The procedure was first suggested by Skinner on the basis that extending lymphadenectomy can improve the results of advanced locoregional disease (5,6). In this operation, the field of dissection extends proximally along the great vessels up to the level of origin of inferior mesenteric artery (7).

To this end, the posterior parietal peritoneum is incised cranially on the left side along the paracolic gutter and on the right side along the small intestinal mesentery as far as the ligament of Treitz. The fibrolymphatic tissues lateral to, in front of, and between the aorta and inferior vena cava are cleared. Dissection is continued distally to remove the lymphatic tissues along the common iliac arteries (common iliac group) and in the intercommon iliac region (presacral nodes). The procedure is then completed as previously described. The dissected field as well as the cleared anatomic regions is outlined in Figure 19.9A–C. The initial report had indicated that extended lymphadenectomy could provide survival benefit for patients with high-stage disease (8).

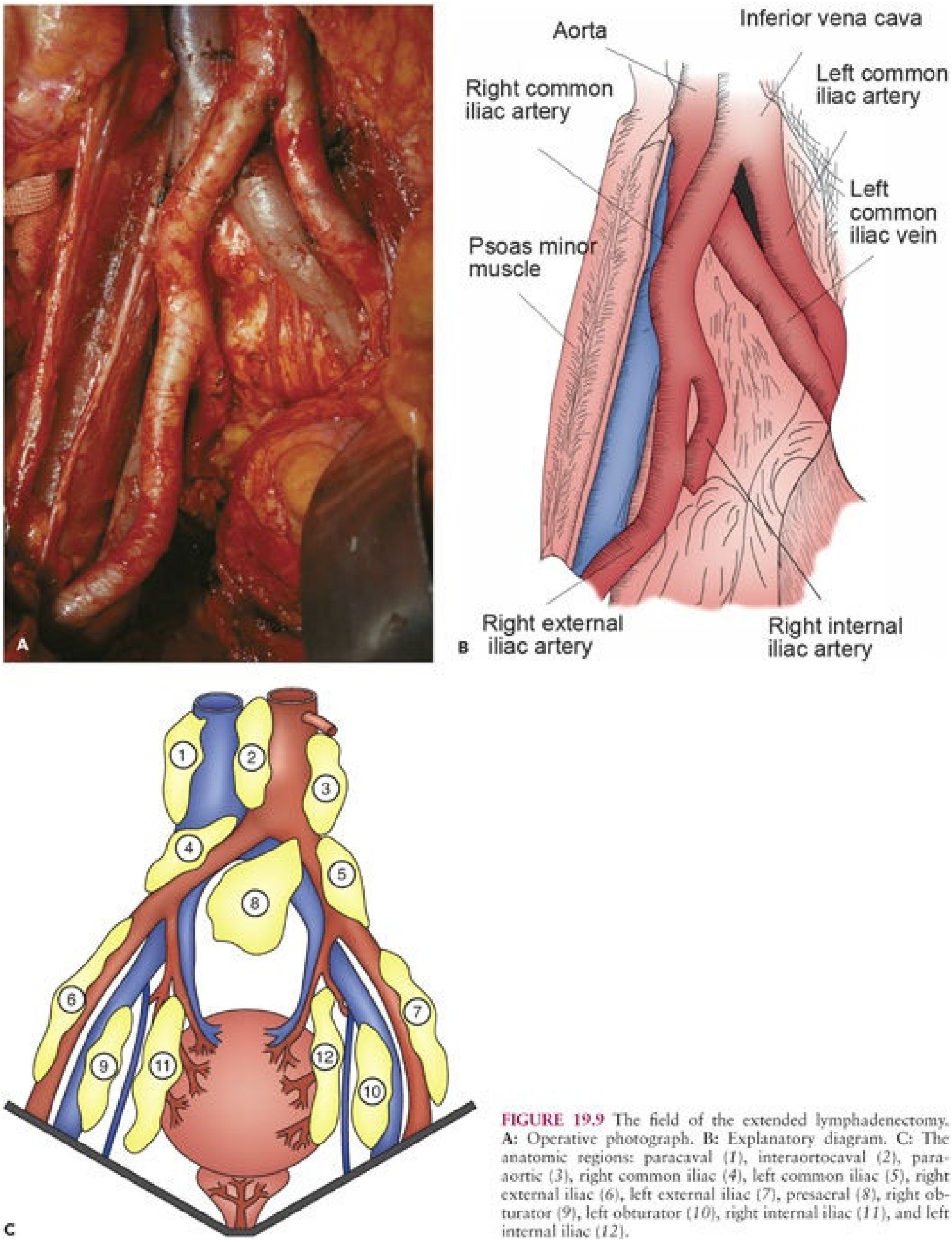

FIGURE 19.9 The field of the extended lymphadenectomy. **A:** Operative photograph. **B:** Explanatory diagram. **C:** The anatomic regions: paracaval (*1*), interaortocaval (*2*), para-aortic (*3*), right common iliac (*4*), left common iliac (*5*), right external iliac (*6*), left external iliac (*7*), presacral (*8*), right obturator (*9*), left obturator (*10*), right internal iliac (*11*), and left internal iliac (*12*).

One-Stage Cystoprostatourethrectomy

Urethrectomy is indicated in a subpopulation of patients with multifocal tumors, diffuse carcinoma in situ, or tumor involving the bladder neck and/or the prostate. Following incision of the puboprostatic ligaments and control of the prostatic venous plexus described, traction is applied on the cystectomy specimen in a cephalad direction. The urethra is dissected from the urogenital diaphragm with a long pair of dissecting scissors. In this manner, 2 to 3 cm of the membranous urethra can be mobilized. The pelvis is temporarily packed with gauze, and further steps are carried out perineally without urethral transection.

A midline incision in the perineum is usually employed. The skin, subcutaneous tissue, and the bulbocavernosus muscle are incised in the midline. The Foley catheter can now be palpated in the urethra. The urethra is dissected sharply from the overlying corpora cavernosus. Further dissection is carried out in the direction of the glans penis. Traction on the urethra results in inversion on the penis, allowing dissection of the urethra as far as the coronal sulcus. The penis is then allowed to restore its normal position. The urethral meatus is circumscribed sharply, and the glans penis is incised in the midline to allow dissection of the fossa navicularis. The entire penile urethra is now free. The glans penis is reconstructed by a few sutures of interrupted 3-0 chromic catgut.

Attention is now focused on dissection of the bulbar urethra. The relatively avascular tissues ventral to the bulbar urethra and beneath the symphysis pubis are dissected first. Thus, the corresponding part that had been previously dissected in the pelvis can be reached, and the pelvic and perineal exposures joined. Dissection is further developed laterally and posteriorly with control of the bulbar urethral arteries. In this manner, the urethra is freed totally, and the whole specimen is removed in one block (Fig. 19.10A–H).

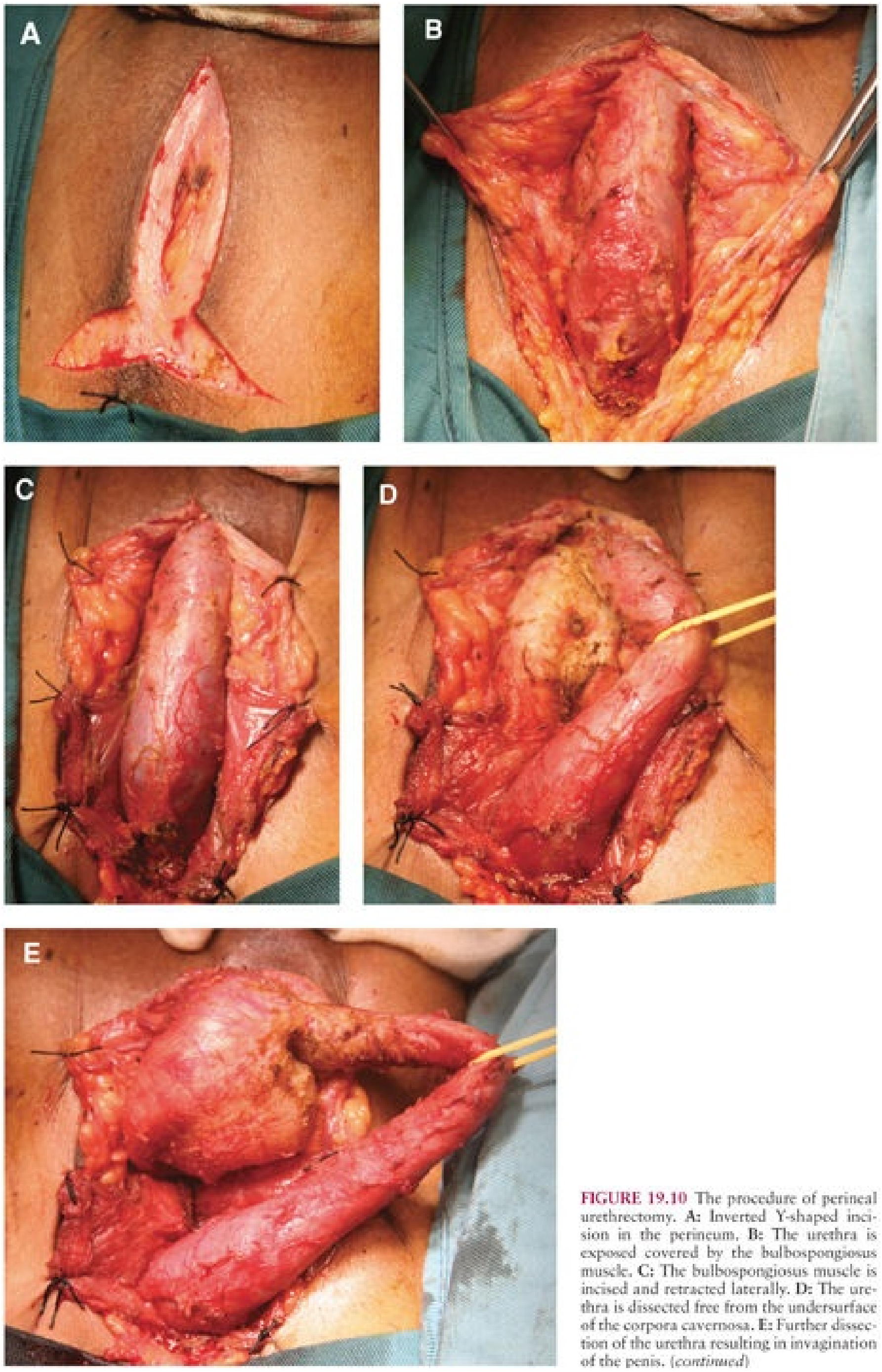

FIGURE 19.10 The procedure of perineal urethrectomy. **A:** Inverted Y-shaped incision in the perineum. **B:** The urethra is exposed covered by the bulbospongiosus muscle. **C:** The bulbospongiosus muscle is incised and retracted laterally. **D:** The urethra is dissected free from the undersurface of the corpora cavernosa. **E:** Further dissection of the urethra resulting in invagination of the penis. (*continued*)

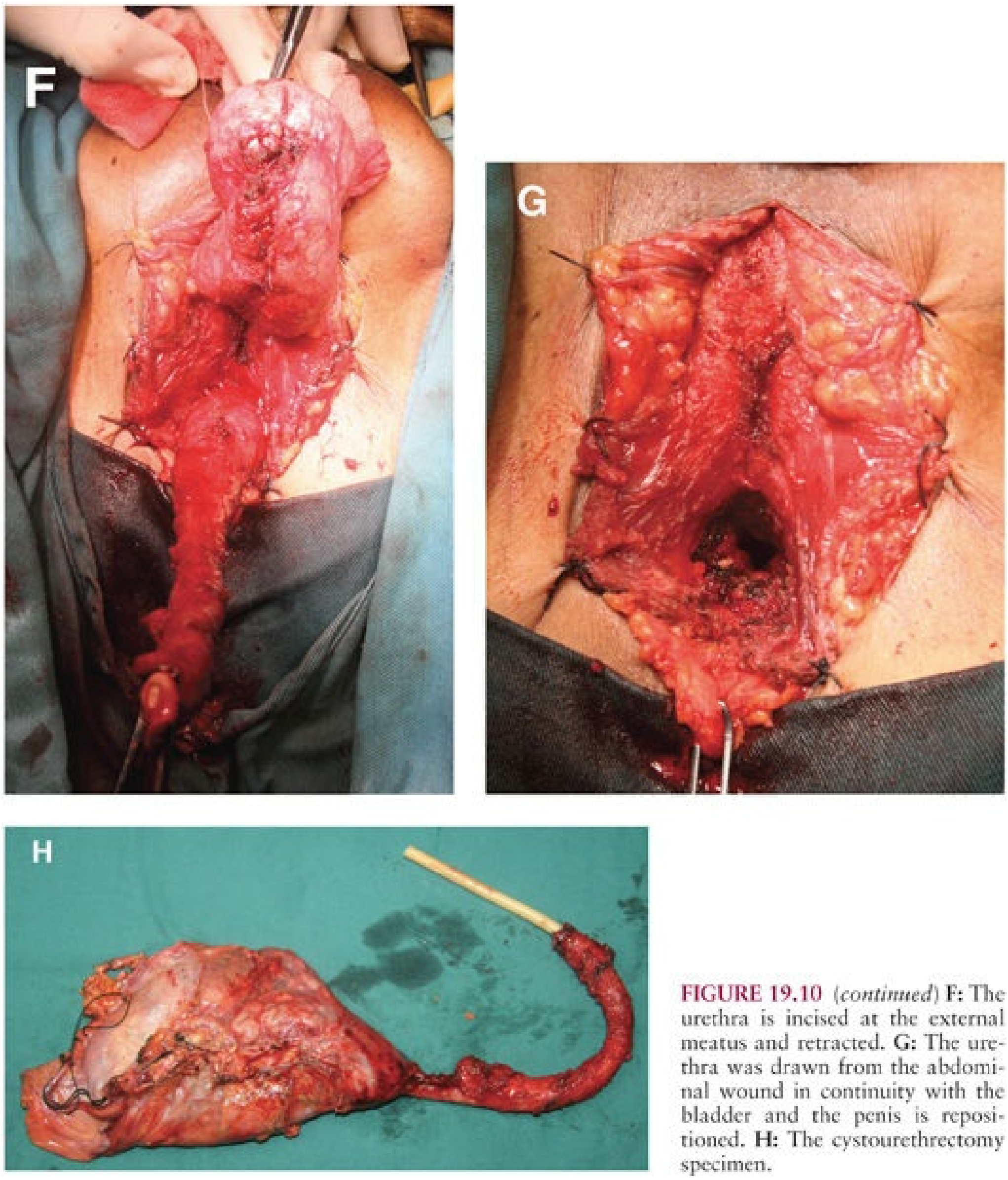

FIGURE 19.10 *(continued)* **F:** The urethra is incised at the external meatus and retracted. **G:** The urethra was drawn from the abdominal wound in continuity with the bladder and the penis is repositioned. **H:** The cystourethrectomy specimen.

Alternatively, the procedure can be carried through a prepubic approach (9). The prepubic area is exposed by extending the midline incision over the pubis until the root of the penis is exposed. The root of penis is held with the index finger of the left hand and by continuous upward traction; the penile body is brought into the prepubic incision. The Buck fascia is then incised to expose the distal urethra. The corpus spongiosum is sharply dissected off the corpora cavernosa and freed from the body of penis until the fossa navicularis and urethral meatus are reached. The urethra is transected distally and the dissection continues proximally toward the root of penis. A right-angle clamp is then passed from the pelvic area and the distal urethra is grasped and brought in to the pelvis with special attention to control the bulbar vessels. Finally, the entire urethra can be pulled safely from the abdominal incision.

Radical Cystoprostatectomy with Orthotopic Bladder Substitution

A standard radical cystoprostatectomy is performed except that the final stages of the operation must be done with attention to detail to avoid damage to the urethra and periurethral musculature. The integrity of these structures has a central role in the functional success of orthotopic substitution. Following lymphadenectomy and control of the pedicles, the endopelvic fascia on either side of the prostate is opened by the tip of a blunt pair of scissors. A right-angle clamp is used to lift the fascia from the underlying venous plexus, and then it is further incised medially until the puboprostatic ligaments are reached. These ligaments are carefully severed at the point of their insertion in the pubic bone. The prostatic venous plexus is controlled by one or two suture ligatures of 3-0 polyglactin just distal to the vesicoprostatic junction. A transverse incision is made proximal to these sutures and extended by sharp dissection with scissors toward the apex of the prostate. The catheter is palpated in the urethra, the anterior wall of which is then incised just distal to the prostatic apex. The exposed Foley catheter is transected, clamped, and held for traction. At this point, three stay sutures of 4-0 polyglactin are placed through the urethra at the 3, 9, and 12 o'clock positions, incorporating the mucosa as well as the periurethral musculature (Fig. 19.11). These sutures prevent retraction of the urethra following its complete transection and are used later for the urethroileal anastomosis. The posterior urethral wall is then incised to expose the dorsal fibrous raphe formed by the fascia of Denonvilliers, which is lifted from the anterior surface of the rectum by a right-angle clamp and divided. The divided fascia is then included in two posterior stay sutures at the 5 and 7 o'clock positions for its later incorporation in the urethroenteric anastomosis (Fig. 19.12A and B).

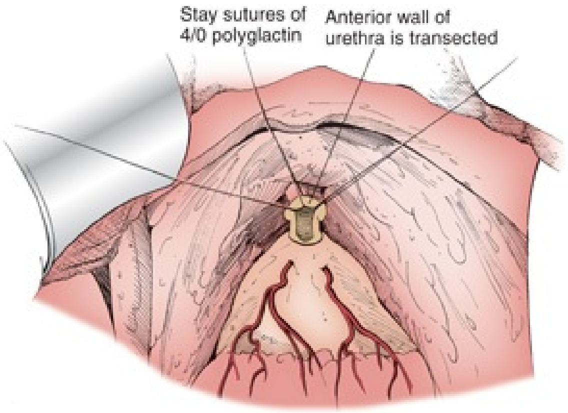
Stay sutures of 4/0 polyglactin
Anterior wall of urethra is transected

FIGURE 19.11 Preparation of the urethral stump for orthotopic substitution. The anterior wall of the urethra is transected. Three stay sutures of 4-0 polyglactin are placed through the urethra at the 3, 9, and 12 o'clock positions.

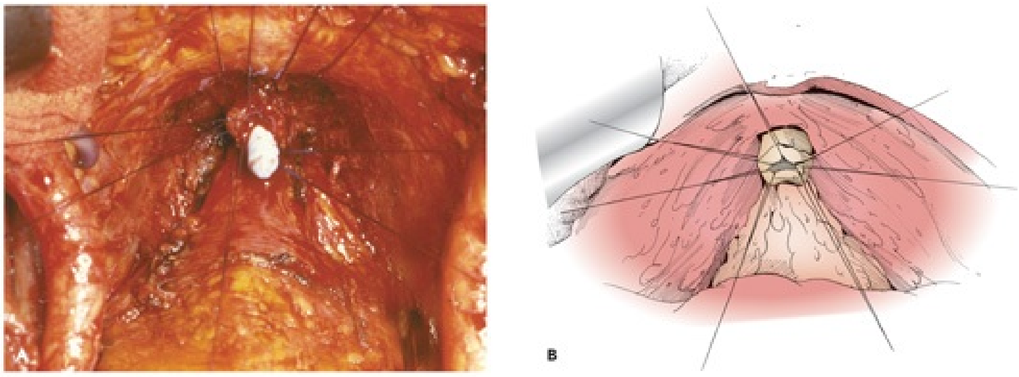

FIGURE 19.12 Transection of the urethra is completed and further stay sutures applied. These will prevent retraction of the urethral stump and will be later used for the urethroileal anastomosis. A: Operative photograph. B: Explanatory diagram.

Radical Cystoprostatectomy with Nerve Sparing

This procedure was initially described by Schlegel and Walsh (10). It can be carried out in an antegrade or a retrograde manner, although in our practice, we prefer the antegrade approach. During radical cystectomy, there are two points where the neurovascular bundle could be injured: (a) posterolateral to the prostate and (b) behind the seminal vesicles. If the extent of the pathology allows the surgeon to avoid these areas, potency could be preserved.

Bilateral lymphadenectomy with creation of the space between the rectum posteriorly and the bladder, seminal vesicles, and prostate anteriorly is carried out as previously described. By a combination of blunt and sharp dissection, the lateral surface of the seminal vesicles is freed from the medial aspect of the vesicoprostatopelvic fascia. This allows the control of these ligaments at a more ventral plane. As a result, the neurovascular pathway behind the seminal vesicles is avoided. These pedicles are controlled by a series of simple interrupted sutures of 3-0 Vicryl. The use of heavy clamps, clips, and diathermy should be avoided. The dorsal vein complex is now controlled, and the urethra isolated carefully from the adjacent fascia. The urethra is then transected, and the Foley catheter is clamped and held for traction. The prostate can thus be elevated superiorly. A right-angle clamp is used to identify branches of the neurovascular bundle to the prostate. These are ligated and divided, freeing the prostate from all its lateral attachments.

Prostate-Sparing Radical Cystectomy

Several authors have advocated retaining the prostate in some selected patients for whom orthotopic diversion is contemplated (11,12). It was suggested that preserving the prostate in whole or in part can circumvent problems related to continence and results in the preservation of erectile functions. However, serious concerns were raised by other authorities of the possible increased oncologic risk following such a procedure. In a review by Hautmann and Stein (13), it was reported that the incidence of prostatic carcinoma in cystoprostatectomy specimens ranged between 29% and 46% and that of prostate transitional cell carcinoma (TCC) between 33% and 58%. In a prospective pathologic evaluation of 425 cystoprostatectomy specimens at our institution, there was histologic evidence of adenocarcinoma of the prostate in 21.2% of cases and concomitant noncontiguous TCC in 6.4% (14). In view of all of these observations, we feel that the potential oncologic risks of prostate-sparing cystectomy outweigh any small and possible functional benefits. Properly conducted radical cystoprostatectomy with orthotopic substitution should remain the standard for treating invasive bladder tumors.

Postoperative Management

Intravenous alimentation and nasogastric suction are maintained until normal bowel activity is resumed. We continue systemic antibiotics for 3 days postoperatively. Chest exercises and physiotherapy to the lower limbs should be carried out. Subcutaneous heparin should be administered if indicated. The tube drains are removed when drainage becomes <100 mL per day. It is advisable to estimate the creatinine content of the fluid to ensure that it is not the result of a urinary leak. Patients with an ileal conduit can be discharged on the 10th to the 12th postoperative day. Following orthotopic substitution, patients are usually kept in the hospital for 3 weeks. Before discharge, a pouchography is carried out to make sure that there are no leaks from the neobladder or from the urethroileal anastomosis.

OUTCOMES

Complications

The two most serious complications that may occur during the procedure are excessive blood loss and rectal perforation. Sudden massive bleeding is usually venous in origin, arising from tributaries of the external iliac vein during the lymphadenectomy: the deep circumflex iliac vein laterally and an abnormal obturator vein medially. Since both are located near the inguinal ligament good retraction, illumination, and suction are needed. A laceration of the external iliac vein is then sutured with 5-0

Prolene.

Another source of bleeding is in relation to the dorsal vein complex. Dissection of this area has to be deferred to the final phase of the procedure. This venous complex is usually injured when the puboprostatic ligaments are incised. Compression of the bleeding area by a piece of gauze (4 × 8 cm) and the tip of a long thin blade of a Deaver retractor is necessary until the dissection of the urethra is completed. Thereafter, bleeding is controlled by one or two interrupted 3-0 sutures of polyglactin acid placed between the two medial borders of the levator ani muscles.

The most serious source of bleeding is typically from the internal iliac vein or one of its tributaries. Sudden excessive bleeding occurs from the depth of a narrow deep recess. Blind attempts to control the bleeding with clamps usually fail and result in more damage. In our experience, one has to achieve an initial temporary control by packing. One or two 4 × 8 cm pieces of moist gauze are sufficient. The pack is tightly and constantly compressed for a few minutes and then is left in place. The operator should proceed with further operative steps until the specimen is removed. Now, the working space is wide enough to allow manipulations under vision. The ipsilateral external iliac and common iliac veins as well as the main stem of the internal iliac artery are controlled by bulldog clamps. The gauze pack is then removed. There will still be some back bleeding, but with the help of a little suction, the bleeding vessels are readily located and easily secured by suture ligation using 4-0 silk.

The other serious intraoperative complication is rectal perforation. This usually takes place during the final phase of the operation if the space between the prostate and rectum was not adequately and completely opened. Under such circumstances, traction on the specimen will lead to tenting of the anterior wall of the rectum. Sharp dissection with scissors or application of clamps would result in an injury of the anterior wall of the rectum well below the peritoneal reflection. If this injury is recognized, the tear is meticulously repaired. The edges are trimmed and closed in two layers using 3-0 polyglactin acid: the first through and through, and the second inverting as a fascia muscular layer (Lembert technique). An omental flap is raised, brought down to the pelvis, and sutured over the repair for additional security. The pelvic cavity is then thoroughly irrigated with l% solution of kanamycin in saline. At the end of surgery, while the patient is still under anesthesia, anal dilation is carried out up to three to four fingers to establish adequate decompression. Generally, by following these principles, one can avoid the need of a temporary proximal colostomy.

The 90-day mortality rate following a contemporary cystectomy is 2.3% (15). Infectious complications were most common (24%) followed by genitourinary (17%), gastrointestinal (15%), and wound-related complications (9%). Septic complications including abdominal and/or pelvic abscesses, wound sepsis, and septicemia are treated by the appropriate antibiotics and drainage of the infected collection. This is best achieved by ultrasound-guided aspiration and/or by insertion of a percutaneous tube drain. Urinary collections (urinoma) are drained under ultrasound guidance. If the source of leak is the ureterointestinal anastomosis, a percutaneous nephrostomy tube is inserted until healing is achieved and checked with an antegrade study. Prolonged ileus is treated by nasogastric suction, intravenous alimentation, and hyperalimentation if necessary. Wound dehiscence should be immediately repaired by proper closure using tension sutures.

Results

Radical cystectomy has evolved as the standard therapeutic modality for muscle-invasive bladder cancer. It can be accomplished with very low mortality, and technical innovations with nerve sparing and orthotopic substitution can provide many patients with a good quality of life with minimal functional losses.

All contemporary series demonstrate that radical cystectomy can result in a substantial rate of cure with overall survival ranges between 44.3% and 58% (1,16). For low-stage tumors (<T2), the survival could be as high as 75%. With further stage progression, the survival expectancy is decreased. Radical cystectomy with pelvic lymphadenectomy also provides a survival advantages for cases with nodal disease (5-year recurrence-free survival in the range of 34% to 43%) (17). Cisplatin-based neoadjuvant chemotherapy has demonstrated a 5% overall survival benefit and should be incorporated into the management decision of all eligible patients with muscle-invasive bladder cancer (18). Evidence has also been provided that adjuvant cisplatin-based polychemotherapy improves the chances of survival among patients with advanced locoregional disease (19).

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CHAPTER 20 RADICAL CYSTECTOMY IN WOMEN

MIRIAM HADJ-MOUSSA, JOANNE LUNDGREN, CHERYL T. LEE, AND TODD M. MORGAN

In 2013, 72,000 new cases of bladder cancer were diagnosed in the United States; almost 17,000 occurred in women, with 4,300 dying from their disease (1,2). Although most urothelial carcinomas are noninvasive, up to one-third of patients present with muscle-invasive disease. In addition, 15% to 30% of patients presenting with non–muscle-invasive tumors will eventually progress to muscle invasion. Radical cystectomy remains the most effective single-modality treatment for patients with muscle-invasive bladder cancer, refractory high-risk non–muscle-invasive disease, and especially lymph-node negative disease with reported 10-year recurrence-free survival of organ-confined lymph-node negative (≤pT2N0) disease between 69% and 87% (3,4). Improvements in processes of care, particularly at high-volume centers, have led to a reduction in perioperative mortality and long-term survival, further strengthening the role of cystectomy (5–8).

Historically, radical cystectomy in women has posed several technical challenges and concerns, including (a) bleeding from the paravaginal tissues and venous plexus around the urethra, which can be brisk and tedious to control; (b) an intraoperative position change for the surgeon during urethrectomy; and (c) vaginal reconstruction, which can be complex, requiring tissue flaps to maximize organ function.

More recently, additional challenges have related to female organ preservation. Radical cystectomy in women has traditionally been equated with anterior exenteration, including resection of the bladder, urethra, uterus, ovaries, and the anterior one-third of the vagina. This approach is certainly indicated for extensive posterior invasive bladder tumors at risk for reproductive organ involvement. However, tumor involvement of adjacent reproductive organs is rare, suggesting that the routine removal of female reproductive and sex organs is not necessary to achieve local cancer control (9). Studies have yet to identify female patients with skip lesions involving the urethra, allowing surgeons to proceed with nonstomal diversions when intraoperative frozen-section analysis of the urethral margin is negative (10,11). Moreover, the increasing attention to preserving quality of life after cancer surgery provides another incentive to spare part or all of the reproductive organs and urethra when feasible.

INDICATIONS FOR SURGERY

Radical cystectomy is indicated for patients with muscle-invasive urothelial malignancy or non–muscle-invasive disease refractory to transurethral resection and intravesical therapy. Additionally, select patients with high-risk non–muscle-invasive disease may elect to undergo so-called “early cystectomy” at the time of their initial presentation. The presence of intractable local symptoms, failure of bladder preservation strategies, and divergent histology are other indications for radical cystectomy.

Muscle-Invasive Disease

The standard therapy for muscle-invasive bladder cancer in women is radical cystectomy. Survival after cystectomy for muscle-invasive disease is closely related to pathologic tumor stage. In patients without lymph node involvement, Stein et al. (4) reported 10-year recurrence-free survival rates of 87% in T2, 76% in T3, and 45% in T4 disease. Lymph node involvement varies with tumor stage, ranging from 18% of patients with T2a disease to 45% of patients with T3/T4 disease, and the 10-year recurrence-free survival rate in these patients was reported to be 34%.

Non–Muscle-Invasive Disease

Radical cystectomy should seriously be considered as an alternative to intravesical therapy in patients with high-grade T1 disease which is (a) recurrent, (b) associated with carcinoma in situ, and/or (c) combined with adverse histologic features (mixed histology, lymphovascular invasion, inverted growth pattern, or nested variant). Patients with non–muscle-invasive disease resistant or refractory to endoscopic resection and intravesical therapy (particularly bacille Calmette-Guérin) are at significant risk of progression, and repeated courses of intravesical therapy can compromise overall survival (12,13). This may be due to the 30% incidence of understaging in patients with noninvasive disease (13). Divergent histology is identified on 25% of transurethral resection of bladder tumor specimens and has been shown to correlate with high-grade and invasive disease (14).

Failure of Alternative Therapies

Alternatives to cystectomy can include systemic chemotherapy, radiation therapy, and aggressive transurethral resection of the tumor, ideally in combination. Although there are no randomized trials comparing bladder-sparing regimens with radical cystectomy, these bladder-sparing modalities have historically been offered to patients who have a solitary tumor <5 cm in size, clinical stage T2 disease without hydronephrosis, minimal or no carcinoma in situ, and no evidence of extravesical disease. Patients who are poor surgical candidates (due to age or medical comorbidities) or refuse cystectomy are also considered for organ preservation strategies.

A significant proportion of these patients will have a complete response to maximal endoscopic resection with chemoradiation (15). More recently, newer chemoradiation regimens have been proposed, even for clinical T1 tumors, in an effort to provide greater sexual and urinary quality of life in bladder cancer patients (16). Concurrent chemoradiation does appear to be more effective than radiotherapy alone, with a phase 3 trial showing 48% 5-year survival in a cohort receiving fluorouracil and mitomycin compared to 35% 5-year survival in a cohort receiving radiation alone (17). Lifelong routine surveillance is critical in this cohort, and 30% to 40% of patients will ultimately require salvage radical cystectomy for disease recurrence (15,18).

Intractable Local Symptoms

Side effects of intravesical therapies are generally mild and managed conservatively. More serious side effects including severe bladder contracture are rare, occurring in <1% of patients treated with intravesical therapy; however, these can also be managed with cystectomy (19). This decision requires an active discussion between the physician and patient to balance the risks of surgical intervention with the impact of patient symptoms on quality of life.

PREOPERATIVE CONSIDERATIONS

Age and Medical Comorbidities

While cystectomy is readily applied to younger populations, the elderly often have limited access to radical surgery and are counseled toward nonsurgical interventions. However, cystectomy is often the best treatment option for invasive bladder cancer in the elderly who are in reasonably good health, because they may be more likely to have extravesical disease at the time of cystectomy (20). Invasive urothelial carcinoma is not an indolent disease, with cancer-associated death being high in the first 3 to 4 years. Thus, for an otherwise healthy 75-year-old woman, it may represent the biggest risk to her health. Bladder cancer patients of all ages often have multiple medical comorbidities, impacting both perioperative and long-term all-cause mortality and should be discussed when considering cystectomy (21). Elderly patients, in particular, need to be extensively counseled regarding the risks of surgery because 90-day mortality is as high as 13% in individuals older than 75 years undergoing radical cystectomy (7).

Functional Outcomes and Quality of Life Measures

When proceeding to definitive surgical treatment in the female bladder cancer patient, the physician should consider the woman's age, sexual function, and childbearing status in conjunction with her clinical stage. For premenopausal patients with carcinoma in situ, early invasive disease (T1), or anterior low-volume T2 disease, radical cystectomy should be performed with intent to preserve the vagina, uterus, ovaries, and urethra, potentially preserving sexual and urinary function. In addition, it is important to consider the need to maintain body image by offering continent and orthotopic diversions, the formation of which has been associated with continence rates between 76% and 82% (11,22,23). Even after the initial postoperative adjustment period, Gacci et al. (24) showed that incontinent diversions were associated with significantly lower rates of physical and emotional well-being in female bladder cancer patients. Table 20.1 outlines our paradigm for the extent of surgical intervention. Indications for urinary diversion are outlined in Section I of this book.

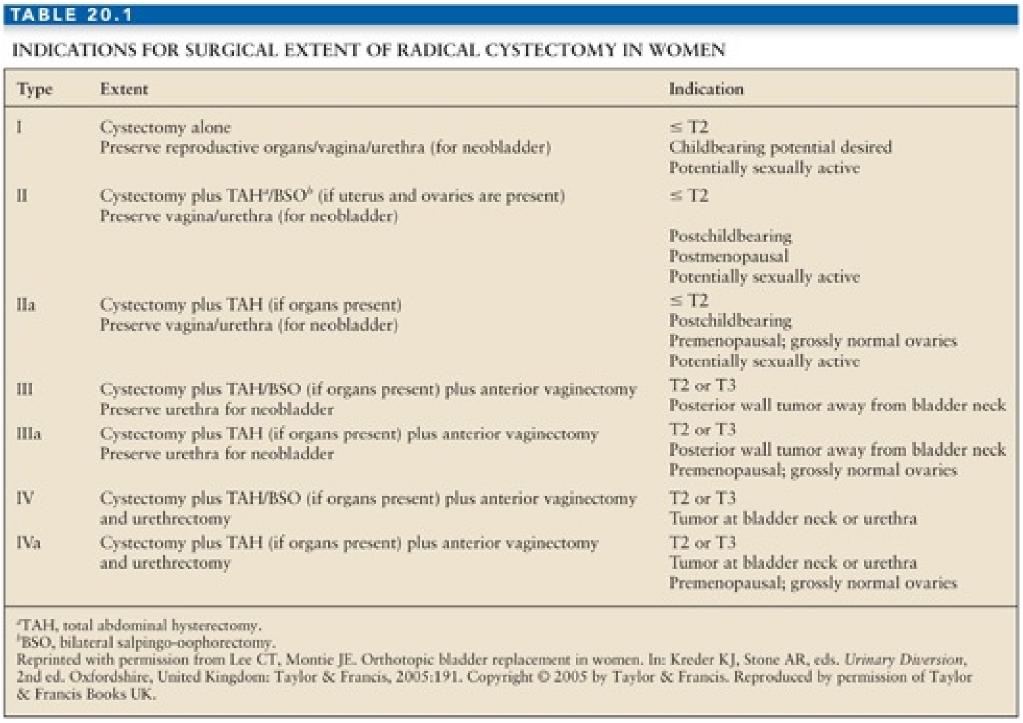

TABLE 20.1

INDICATIONS FOR SURGICAL EXTENT OF RADICAL CYSTECTOMY IN WOMEN

Type	Extent	Indication
I	Cystectomy alone Preserve reproductive organs/vagina/urethra (for neobladder)	≤ T2 Childbearing potential desired Potentially sexually active
II	Cystectomy plus TAH[a]/BSO[b] (if uterus and ovaries are present) Preserve vagina/urethra (for neobladder)	≤ T2 Postchildbearing Postmenopausal Potentially sexually active
IIa	Cystectomy plus TAH (if organs present) Preserve vagina/urethra (for neobladder)	≤ T2 Postchildbearing Premenopausal; grossly normal ovaries Potentially sexually active
III	Cystectomy plus TAH/BSO (if organs present) plus anterior vaginectomy Preserve urethra for neobladder	T2 or T3 Posterior wall tumor away from bladder neck
IIIa	Cystectomy plus TAH (if organs present) plus anterior vaginectomy Preserve urethra for neobladder	T2 or T3 Posterior wall tumor away from bladder neck Premenopausal; grossly normal ovaries
IV	Cystectomy plus TAH/BSO (if organs present) plus anterior vaginectomy and urethrectomy	T2 or T3 Tumor at bladder neck or urethra
IVa	Cystectomy plus TAH (if organs present) plus anterior vaginectomy and urethrectomy	T2 or T3 Tumor at bladder neck or urethra Premenopausal; grossly normal ovaries

[a] TAH, total abdominal hysterectomy.
[b] BSO, bilateral salpingo-oophorectomy.
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PREOPERATIVE CARE

Optimization of preoperative performance and nutritional status helps reduce the risk of perioperative complications and may be associated with improved perioperative as well as overall survival (2,25). Patients are encouraged to augment their diet with protein and caloric supplements if they have anorexia or significant unintended weight loss. Although mechanical bowel preparation was formerly the standard of care, increasing evidence over the past 10 years has suggested that this is likely unnecessary and can be safely omitted in patients undergoing urinary diversion with small intestine. Large et al. (26) showed that a GoLYTELY (polyethylene glycol/electrolytes) bowel prep did not appear to impact rates of perioperative infection or bowel complications. In another study, where patients were prospectively randomized to undergo or not undergo mechanical bowel preparation prior to radical cystectomy and ileal urinary diversion, a nonstatistically significant increase in complication rate was observed in the group receiving a bowel preparation (27). Wound prophylaxis is achieved in the perioperative period with a second-generation cephalosporin antibiotic administered over a 24-hour period.

The authors of this chapter have also begun short-term perioperative administration of alvimopan (Cubist Pharmaceuticals, Inc, Lexington, Massachusetts) for most patients because it has been shown to reduce the time to return of bowel function and is well tolerated by patients (28). Alvimopan is contraindicated in patients who have taken opioids for more than a week prior to surgery and patients with end-stage renal disease. Patients should be counseled regarding a potential increase in the risk of myocardial infarction, although this has not been observed with short-term alvimopan use. Pneumatic compression stockings and 5,000 units of low-dose unfractionated subcutaneous heparin are administered prior to induction of anesthesia for deep venous thrombosis prophylaxis. Enhanced Recovery After Surgery pathways have been used to reduce complications and length of stay after colorectal surgery and are being studied for cystectomy patients to optimize perioperative care (29).

SURGICAL TECHNIQUE

Anatomic Considerations

Female Continence

An understanding of the female continence mechanism in women is critical prior to consideration of an orthotopic neobladder. There are two continence mechanisms in women (30). The first is the proximal urethra, smooth muscle fibers of which are innervated by autonomic fibers from the pelvic plexus that course adjacent to the bladder neck and vagina. These nerves often are transected during a radical cystectomy. The second is the rhabdosphincter, intermingled smooth and striated muscle fibers located in the middle to lower one-third of the urethra. Somatic innervation of the striated muscle fibers is via the pudendal nerve and appears to be the critical sphincter mechanism for continence in women (30). Because the rhabdosphincter is present in the middle to lower urethra, and the somatic nerves run below the endopelvic fascia along the levator ani, the entire bladder and bladder neck can be resected without compromising eventual continence. Importantly, complete resection of the bladder is necessary to minimize the amount of transitional epithelium left behind and thus reduce the risk of local tumor recurrence as well as hypercontinence after orthotopic urinary diversion. Alteration in the anatomic relationships between the remnant urethra and its fascial attachments also contribute to incontinence, so care should be taken to preserve the endopelvic fascia and pubourethral ligaments in patients undergoing orthotopic neobladder creation in order to minimize the risk of long-term incontinence (10).

Female Sexual Function

A similar pelvic plexus supporting erectile function exists in both men and women. Anterior exenteration with removal of the urethra has been shown to result in clitoral devascularization with decreased sexual arousal due to disruption of the neurovascular bundles lateral to the anterior vagina (31). In addition, resection of the vagina is often associated with disruption of the autonomic neurovascular plexus, further compounding the impact on sexuality. Meticulous preservation of all of the lateral portions of the vaginal wall as well as the urethra can avoid injury to the pelvic plexus and may reduce the impact on sexual function (32). Furthermore, vaginal reconstruction after vaginectomy traditionally results in a greatly shortened or narrowed vault often not compatible with vaginal intercourse (33). The physical and psychosocial ramifications greatly undermine sexual function. Similarly, the presence of an incontinent stoma can greatly affect female sexual function and body image following cystectomy (24). In a retrospective study of Egyptian women who had undergone non–nerve-sparing cystectomy, El-Bahnasawy et al. (22) found stomal diversions to be associated with significantly reduced sexual function.

Anterior Exenteration

Patients are positioned in either a modified lithotomy position with Allen-type stirrups or in a frog-leg position in order to allow sterile access to the vagina and urethra. The vagina and perineum must be well prepared with an iodine or Betadine scrub. An infraumbilical vertical midline incision gives ideal exposure; however, patient habitus or a planned extended lymph node dissection may necessitate an extension of this incision another 2 to 3 cm superiorly. The urachal remnant provides a convenient handle for traction on the bladder (Fig. 20.1). The peritoneum is divided along the lateral umbilical ligaments (Fig. 20.2), and the round ligament is ligated and divided. A self-retaining retractor, such as a Bookwalter device or omnitractor, will maintain exposure. The fallopian tubes and ovaries are present and nonfunctional in this predominantly postmenopausal population and thus are typically removed with the uterus, cervix, and anterior vagina. The gonadal vessels and suspensory ligament are divided above the ovaries (Fig. 20.3). The ureters are mobilized with substantial periureteral adventitia to preserve optimal blood supply and later divided at the bladder hiatus (Fig. 20.4). Ligation and division of the uterine and vaginal arteries branching from the hypogastric artery is usually required to accomplish this.

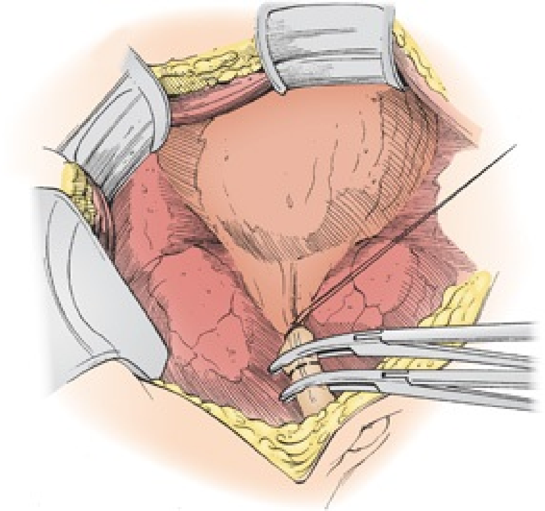

FIGURE 20.1 The urachal remnant provides a convenient handle for traction on the bladder through the case and is divided between Kelly clamps and ligated.

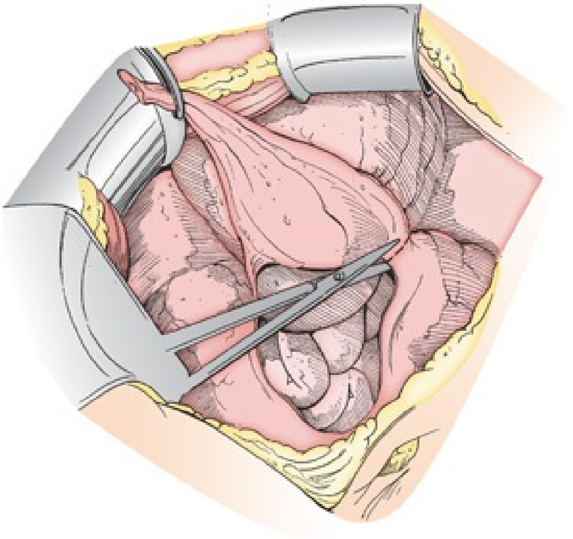

FIGURE 20.2 The division of the peritoneum follows the course of the lateral umbilical ligament until the round ligament is identified, clipped, and divided.

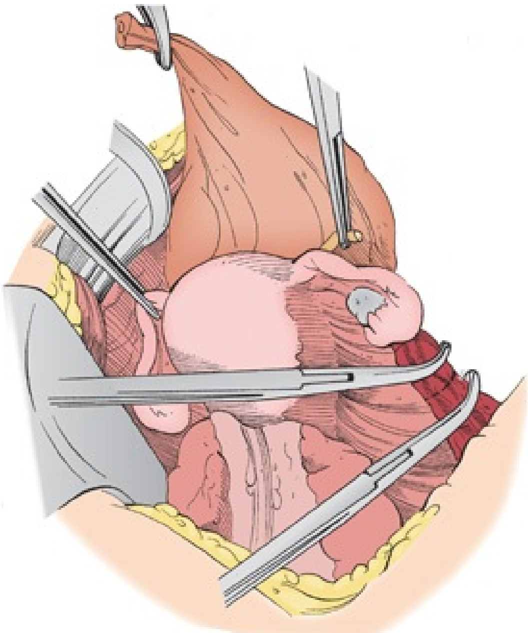

FIGURE 20.3 The fallopian tubes and ovaries, if present, are commonly removed with the uterus and bladder. The gonadal vessels, surrounded by the suspensory ligament, are divided and ligated cephalad to the ovary.

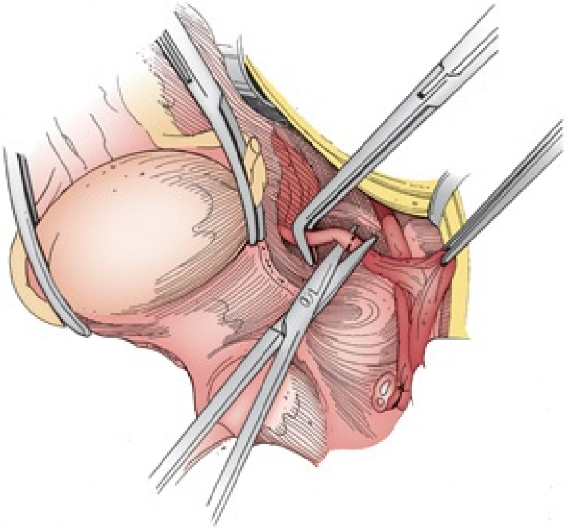

FIGURE 20.4 Each ureter is mobilized with a large amount of periureteral adventitial tissue to preserve optimal blood supply. The ureter is divided a short distance above the bladder.

The lateral blood supply to the bladder and uterus is isolated as it courses from the internal iliac artery and vein. The endopelvic fascia and the perirectal “fat pad” are exposed with medial traction on the bladder and ureter. The index finger is used to bluntly develop a plane just medial to the well-defined superior vesical artery, aiming obliquely toward the perirectal tissue. This will isolate the superior vesical artery, which requires ligation. Several small associated arteries and veins can be ligated and divided at this point, thus controlling the lateral pedicle under direct vision (Fig. 20.5). Medial traction on the bladder with fingers above and below the pedicles enhances exposure. Alternatively, these vessels may be controlled during ligation and division of the vaginal wall (below).

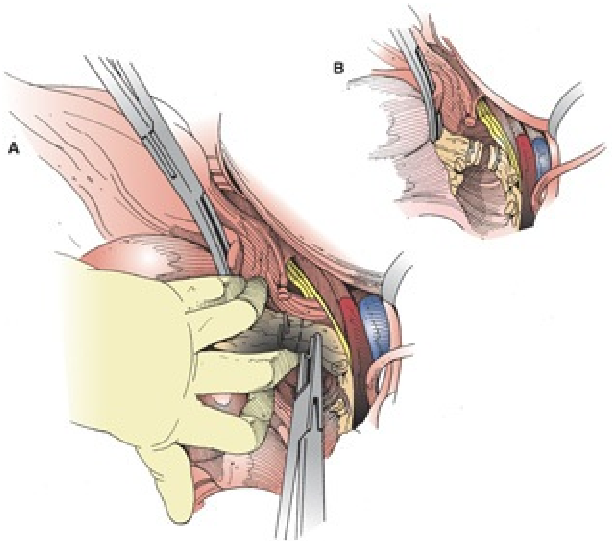

FIGURE 20.5 Division of the lateral pedicle is one of the more important technical aspects of the procedure. The endopelvic fascia should be well exposed with blunt dissection. A perirectal fat pad lying adjacent to the rectum defines the lower limit of the lateral pedicle coursing from the internal iliac vesical. Medial traction on the urachal remnant and retraction of the ureter medially allow an index finger to create a plane just medial to the origin of the superior vesical artery outlining the lateral pedicle. The caudad extent of blunt dissection is the perirectal fat tissue. **A:** The medial traction on the bladder with the surgeon's nondominant hand easily exposes the entire pedicle. **B:** The superior vesical artery is ligated, but the remainder of the small vessels can be controlled with clips on both sides.

After division of the lateral pedicles on each side, the technique is modified depending on the type of extirpative procedure to be performed. In a classic anterior pelvic exenteration, the bladder, uterus, bilateral fallopian tubes and ovaries, anterior vaginal wall, and urethra are removed en bloc (Fig. 20.6). This is warranted for a deeply invasive posterior bladder wall cancer. Alternatively, partial or complete preservation of the reproductive organs can be considered, especially if orthotopic urinary diversion is planned, as described later. To mobilize the anterior pelvic organs, an incision is made in the posterior peritoneum down to the rectovaginal cul-de-sac. Blunt and sharp dissection in the midline mobilizes the posterior vaginal wall; this mobility will allow the posterior vaginal wall to be rolled anteriorly away from the rectum for vaginal reconstruction.

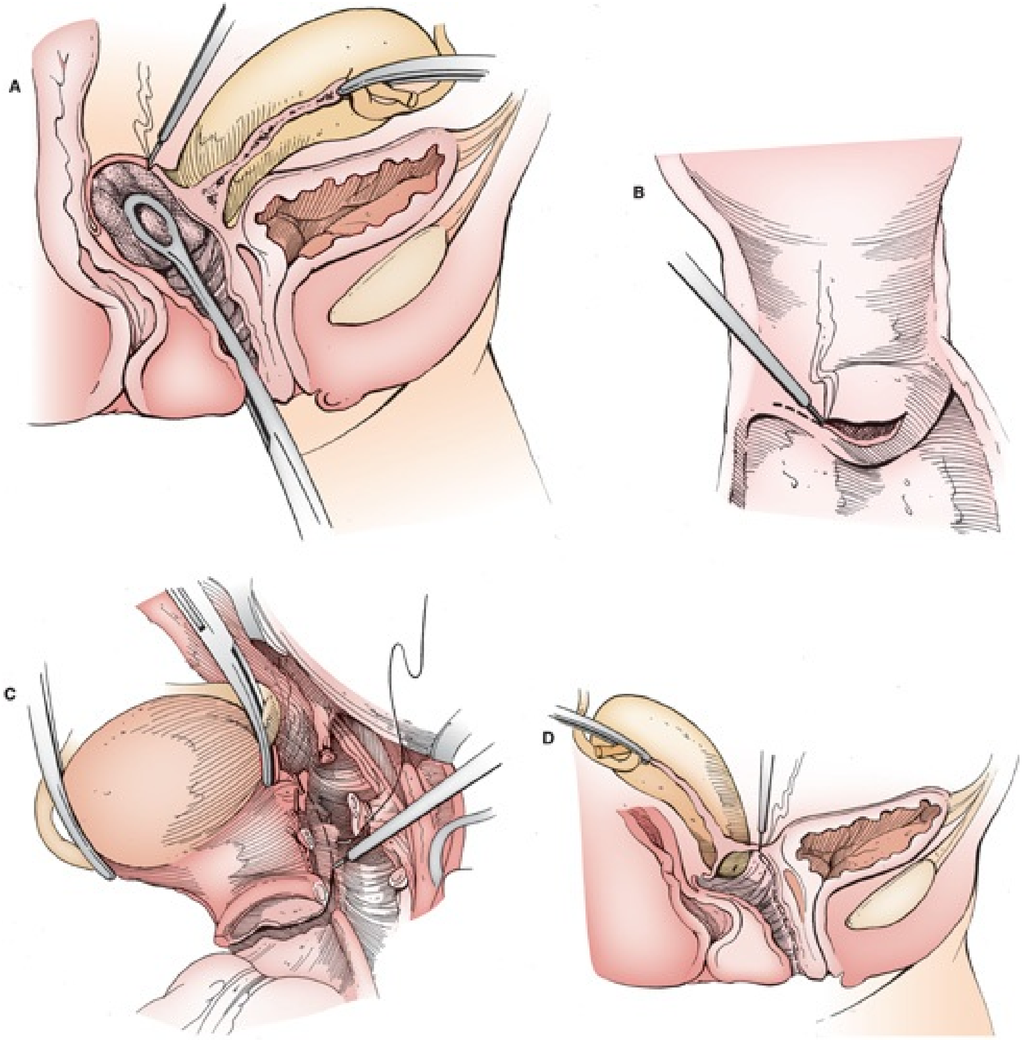

FIGURE 20.6 The classic anterior pelvic exenteration includes removal of the bladder, uterus, bilateral fallopian tubes and ovaries, anterior vaginal wall, and urethra. **A and B:** An incision is made with cautery at the apex of the vagina. This is often facilitated with a Betadine-soaked sponge stick placed in the vagina on upward traction. The incision should be as close as possible to the posterior aspect of the cervix. **C:** The incision is then carried around laterally along the anterolateral aspect of the vagina. There is commonly a rich blood supply to the lateral aspect of the vagina, and this is most easily controlled with multiple suture ligatures in a stepwise fashion. The incision stops just before the endopelvic fascia. **D:** With this dissection, the entire anterior vaginal wall, posterior bladder wall, and urethra are removed en bloc.

A Betadine-soaked sponge stick is placed in the vagina, elevating the apex of the vagina just posterior to the cervix. Cautery is used to open the apex of the vagina in the midline; this incision is carried laterally down the anterior vaginal wall on each side with care taken to remove only a narrow strip of the vaginal wall in order to facilitate vaginal closure (Fig. 20.6A–C). A variety of electrosurgical devices can be useful in this maneuver (e.g., LigaSure, Olympus PKS, harmonic scalpel), greatly minimizing venous bleeding from the vaginal wall. Alternatively, a surgical stapler (e.g., Endo GIA) can be utilized to ligate and divide the vaginal wall. Additional bleeders from the adjacent tissue may be controlled with 2-0 Vicryl suture ligatures and/or hemoclips. This dissection is continued to the bladder neck. If cutaneous diversion is planned, the pubovesical attachments are sharply divided and the proximal urethra is mobilized. Depending on the tumor location, a portion of the proximal urethra can be sharply dissected off of the anterior vaginal wall, which is transected at the bladder neck, leaving a portion of the anterior vaginal wall intact within the pelvis. This preserves a greater portion of the vagina and allows for an easier vaginal reconstruction later. The dissection then moves to the perineum after reasonable hemostasis has been achieved within the pelvis.

Urethrectomy

To perform the urethrectomy, the labia are retracted laterally with suture ligatures. Army-Navy or self-retaining retractors provide exposure to the urethral meatus. An inverted U-shaped incision is made around the urethra (Fig. 20.7A), and the urethra is mobilized anteriorly and laterally. If the patient is in a frog-leg (rather than lithotomy) position, this maneuver is performed by leaning over the perineum. Next, returning to the pelvic approach, suture ligatures are placed in the venous plexus anterior to the urethra, analogous to control of the dorsal venous plexus in men. Further simultaneous antegrade dissection can help to direct the retrograde dissection from the perineum until there is continuity between the pelvis and perineum. Ultimately, the anterior vaginal wall posterolateral to the urethra is divided to connect with the pelvic dissection, permitting removal of the entire specimen. If the patient is frog-legged, more of the dissection can be performed from the pelvic approach by using a finger to hook the Foley catheter where it exits the urethra and pulling it up into the pelvis. This exposes the urethral meatus, which can then be excised in its entirety. Alternatively, a circumferential periurethral incision can be made, preserving a portion of the anterior vagina located posterior to the urethra (Fig. 20.7B and C). Subsequent simultaneous antegrade and retrograde dissection will allow complete urethral mobilization and excision, as noted earlier.

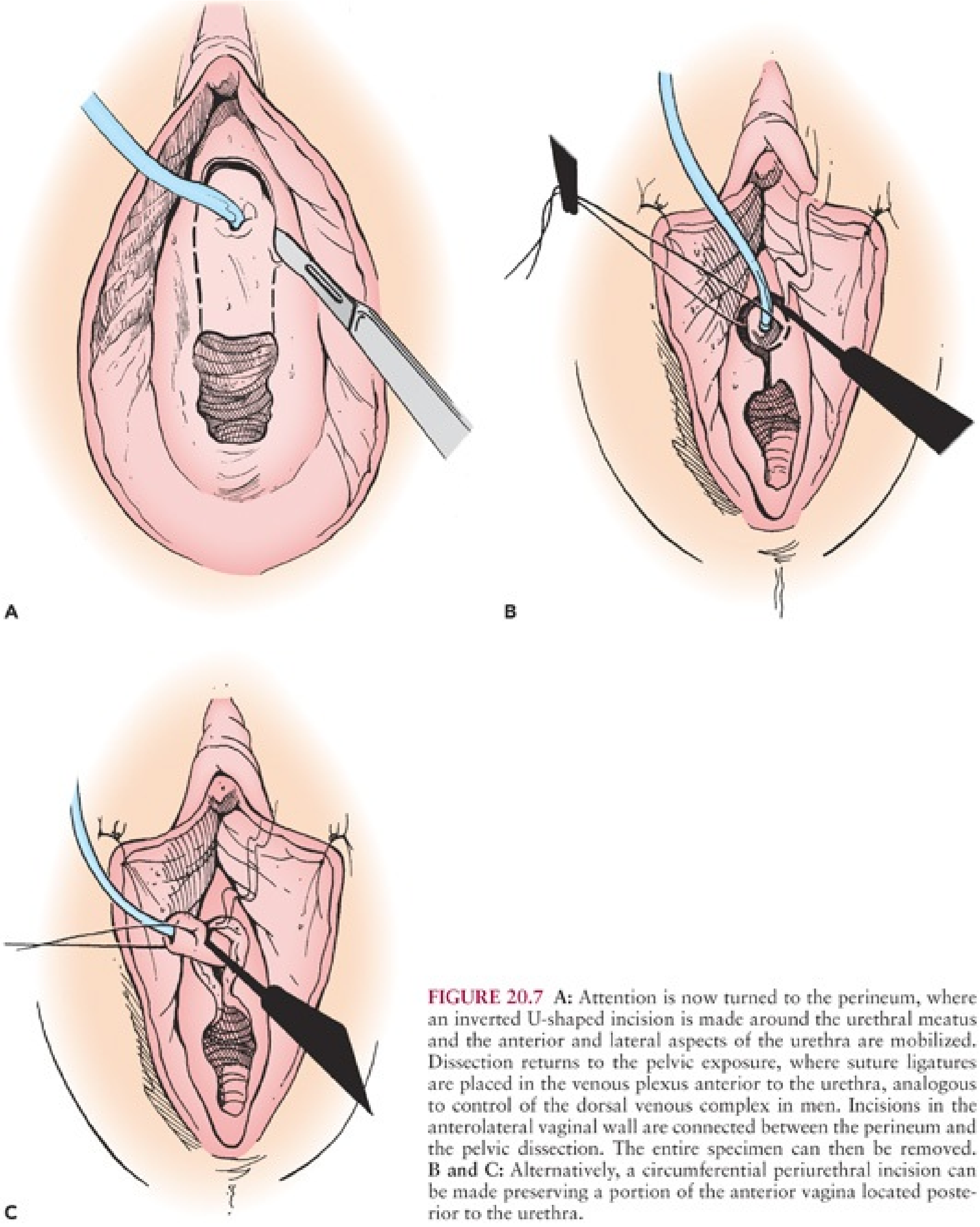

FIGURE 20.7 **A:** Attention is now turned to the perineum, where an inverted U-shaped incision is made around the urethral meatus and the anterior and lateral aspects of the urethra are mobilized. Dissection returns to the pelvic exposure, where suture ligatures are placed in the venous plexus anterior to the urethra, analogous to control of the dorsal venous complex in men. Incisions in the anterolateral vaginal wall are connected between the perineum and the pelvic dissection. The entire specimen can then be removed. **B and C:** Alternatively, a circumferential periurethral incision can be made preserving a portion of the anterior vagina located posterior to the urethra.

Vaginal Reconstruction

The vagina is reconstructed by rotating the apex of the posterior vaginal wall anteriorly in a clamshell fashion in order to create a foreshortened vagina that maintains the previous width (Fig. 20.8). Additional mobilization of the apex of the vagina off of the rectum is sometimes required in order to ensure the vaginal closure is tension-free. A stay suture in the apex of the posterior vaginal wall brings the vaginal wall to the perineum, if a total anterior vaginectomy was required; this flap of vagina is sutured to the periurethral vaginal tissue anteriorly in the midline and then sequentially on each side. After two to three interrupted sutures are placed on each side from the perineum, additional sutures higher up on the vaginal wall are more easily placed from the pelvic exposure. A watertight closure provides optimal hemostasis of the paravaginal tissue.

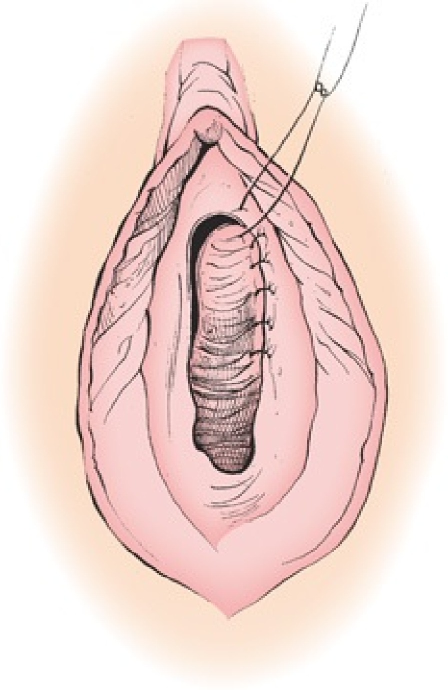

FIGURE 20.8 Several methods of closure of the vagina are feasible. One that appears to supply strong support of the pelvis uses the posterior vaginal wall as a flap to create a neovagina. This foreshortens the vagina but does not narrow it as a side-to-side closure does and thus provides for a better return of sexual function, if appropriate. A suture is placed in the apex of the posterior vaginal wall from above; this is used to bring the posterior flap of the vagina down to the perineum. Several sutures are placed from below, incorporating a full thickness of the periurethral vaginal tissue to the posterior vaginal wall flap. Sutures closer to the apex of the vagina are more easily placed from the pelvic exposure.

If the tumor characteristics permitted partial anterior vaginectomy, and a portion of the anterior vaginal wall was preserved within the pelvis below the bladder neck, the posterior vaginal flap is apposed to this anterior stump within the pelvis (see Fig. 20.8). The lateral walls are then closed sequentially from within the pelvis with running Vicryl suture. Using this approach, a circumferential urethral incision would have been used (Fig. 20.7B), and the prevaginal tissues identified in the perineum would then be sutured to the retropubic tissues with running or interrupted Vicryl suture. A vaginal pack soaked in Betadine or estrogen cream (e.g., Premarin) is left in the vagina for 24 hours.

Reproductive Organ Preservation

In appropriately selected patients, all or part of the female reproductive tract can be preserved. Certainly, the age, childbearing status, and sexual function of the patient must be considered when planning radical extirpative procedures (Table 20.1). If the disease is felt to be organ-confined and located favorably, it is reasonable in young women with childbearing potential to spare the reproductive organs, since it is increasingly clear that most female organs are uninvolved by primary bladder cancer and that local recurrence is uncommon (9,11,34,35). The ovaries, in particular, are very rarely involved (36). When orthotopic diversion is planned in the sexually active postmenopausal woman with a tumor site away from the trigone or bladder neck, the anterior vagina should be preserved.

The surgical approach begins with a similar midline incision as described for anterior pelvic exenteration followed by the development of the extravesical space. The urachus is divided, and peritoneal flaps are developed on either side of the bladder. The round ligament is ligated, and the ureters are mobilized as described previously. A sponge stick is placed in the vagina to readily identify the vaginal apex and cervix and also to provide countertraction. The plane between the posterior bladder and anterior vaginal wall is developed (Fig. 20.9). This dissection must hug the anterior vaginal wall so as not to compromise the cancer surgery but also to avoid the troublesome bleeding that can be encountered when the dissection is in the wrong plane. A potential advantage of this approach is avoidance of the rich vascularity of the vagina, which is appreciated when the entire anterior vaginal wall is resected. During this dissection, care should be taken to avoid entry into the vagina, which could increase the risk of fistula formation when orthotopic diversion is planned. In this circumstance, an omental flap can be used to cover the vaginal repair.

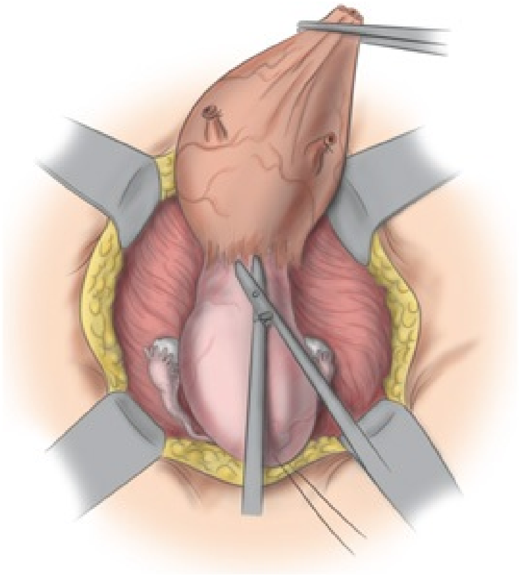

FIGURE 20.9 When partial or complete female pelvic organ preservation is planned with or without orthotopic urinary diversion, a plane is created sharply between the posterior bladder wall and anterior vagina. Care should be taken to avoid entry into the vagina as this increases the risk of fistula formation. Vaginotomies should be closed. (Reprinted with permission from Lee CT, Montie JE. Orthotopic bladder replacement in women. In: Kreder KJ, Stone AR, eds. *Urinary Diversion*, 2nd ed. Oxfordshire, United Kingdom: Taylor & Francis, 2005:190. Copyright © 2005 by Taylor & Francis. Reproduced by permission of Taylor & Francis Books UK.)

If appropriate, the uterus, fallopian tubes, and ovaries may be left in situ. This is an optimal choice for the sexually active female with low-volume or early-stage disease who has concerns about future fertility. If hysterectomy is required after vaginal-sparing surgery, a sharp incision is created at the vaginal apex and carried circumferentially around the cervix, preserving as much vaginal tissue as is feasible. The vaginal cuff is closed using 3-0 Vicryl in a continuous fashion, followed by an additional layer of 2-0 Vicryl interrupted Lembert sutures.

Retrograde Dissection and Urethral-Sparing Technique

In planning for orthotopic diversion, modifications in the technique of pelvic exenteration are necessary when approaching the bladder neck and urethra. It is important to maintain the integrity of the endopelvic fascia and thus preserve the support of the external sphincter in order to facilitate long-term continence. Dissection of the lateral wall of the vagina should also be avoided to prevent injury to the neurogenic innervation of the rhabdoid sphincter. Lastly, the bladder neck must be removed entirely to minimize postoperative urinary retention and maximize the removal of urothelial tissue.

Once the bladder has been mobilized off the vagina down to the bladder neck, fine sutures are used anteriorly in the periurethral tissue as necessary for hemostasis of the venous plexus. The urethra is amputated sharply at the junction with the bladder neck, avoiding distal mobilization or dissection of the urethra (Fig. 20.10). After the bladder has been removed, a sample of the urethra is circumferentially excised from the specimen or the urethral stump (if necessary) and sent for frozen section to ensure a negative urethral margin. Exposure is often ideal for the enterourethral anastomosis which can be aided by applying perineal pressure. The authors prefer six to eight fine absorbable sutures using 2-0 Monocryl, taking small bites on the urethra. Mobility of the intestinal reservoir to the urethra is generally not a problem in women, although it can be in men.

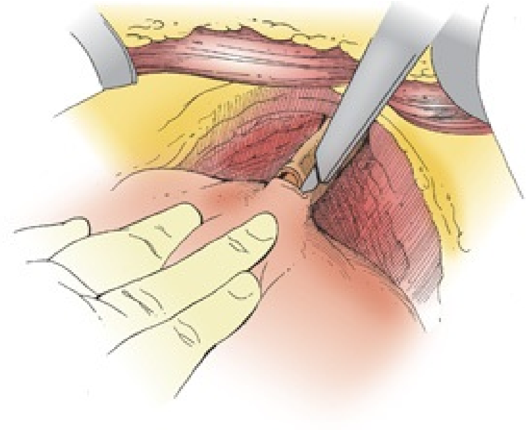

FIGURE 20.10 In the situation in which an orthotopic diversion is planned, neither the endopelvic fascia nor the anterior venous plexus is disturbed. An incision is made in the anterior urethra just distal to the junction with the bladder neck. The urethra is divided completely, and the dissection of the bladder off the anterior vaginal wall can be done in either an antegrade or retrograde fashion.

In the initial experience with orthotopic diversion, the concern for stress incontinence was such that anterior urethral fixation sutures were placed to prevent hypermobility of the urethra. This maneuver is not only unnecessary (unless documented stress incontinence from hypermobility is evident preoperatively) but could also be counterproductive by contributing to increased urinary retention or "hypercontinence." A possible additional mechanism for postoperative urinary retention may be exacerbation of a preexisting but previously insignificant cystocele. After the cystectomy, the urethra is fixed anteriorly and the patient voids by Valsalva maneuver after relaxing the external sphincter. If a cystocele is present, the increased abdominal pressure needed for voiding across the fixed urethra and bladder neck could be blunted by the cystocele. Increasing posterior support of the pouch with ventral suspension near the dome and of the vaginal stump has been described to minimize this side effect (37).

Robotic Cystectomy

There are some specific considerations for female robotic cystectomy. Patients are positioned in the low lithotomy position, the table placed in steep Trendelenburg, and prepped from the xiphoid through midthigh, including the genitals. A Foley catheter is placed and often a vaginal sponge stick or vaginal manipulator. Some surgeons elect to place a uterine manipulator at the beginning of the procedure to facilitate control of the uterus during the surgery (38).

Port placement proceeds in a similar fashion as for a male patient, and, following docking of the robot, the ureters are identified and dissected down to the level of the bladder. In order to maximize ureteral length, the ovarian pedicles can be identified and divided, and the cardinal, round, and uterosacral ligaments may be divided bilaterally prior to ligating and dividing the distal ureters. Next, retracting the uterus anteriorly, the junction between the uterus and posterior vaginal wall is divided. The posterior vaginal fornix is incised transversely and carried down to the vaginal sponge stick or manipulator with care taken to preserve as much vaginal wall as possible. Alternatively, a vaginal-sparing procedure may be performed. Attention is then turned to the anterior dissection where the bladder is dropped off of the abdominal wall. The dorsal venous complex may be suture ligated if necessary. The vaginal wall incisions are carried distally past the urethra so that the urethral meatus can be identified under direct vision and circumferentially incised (39,40). The anterior vaginal wall is removed en bloc with the bladder and urethra and the specimen is placed in an Endo Catch bag, which may be delivered through the vagina. Vaginal reconstruction is then performed.

All modifications performed in the open procedure may also be performed via a robotic approach. For example, in carefully selected patients, a reproductive organ–sparing operation can be performed. The uterus is retroverted, and with the bladder retracted anteriorly, it is carefully dissected off the uterus down to the cervix. The dissection is continued along the anterior vaginal wall and down to the bladder neck being careful not to thin either the vaginal wall or bladder (40).

Postoperative Care

Establishment of a critical care pathway is useful for cystectomy patients (41,42). Compliance with the ideal postoperative course is difficult after cystectomy because of a high frequency of comorbid disease and complications, which may delay discharge even if they are not life-threatening (43,44). Epidural analgesia, patient-controlled analgesia, and nonsteroidal anti-inflammatory agents are useful adjuncts to provide better postoperative pain control, which translates into better pulmonary hygiene, ambulation, and return of bowel function. The authors no longer routinely utilize nasogastric decompression postoperatively, although orogastric decompression can be helpful intraoperatively. Overall, excellent pain control, judicious use of diuretics to combat fluid retention, and aggressive pulmonary toilet are important strategies to prevent complications. Early ambulation, intermittent compression stockings, and unfractionated heparin (5,000 U just prior to the surgery and every 8 hours thereafter) are currently used for deep venous thrombosis prophylaxis (45). Routine perioperative parenteral nutrition is not necessary in the well-nourished patient; however, the clinician should consider this therapy in the early postoperative period for nutritionally debilitated patients or those likely to have prolonged ileus. In our experience, approximately 10% to 20% of patients need postoperative nutritional support.

OUTCOMES

From July 1995 through June 2013, we have performed 1,574 cystectomies; 342 (22%) patients were women. The median age in women was 67 years old. For us, age has not been a deterrent to providing definitive treatment in a patient with a reasonable life expectancy. This is reflected by the fact that 40% of patients undergoing cystectomy at our institution are older than 70 years, including 10% of patients older than 80 years. In addition, 32% of our patients are obese (body mass index >30 kg per m^2), and 49% of patients have an American Society of Anesthesiologists class of 3 or higher, suggesting greater operative risk. Adding to the patient complexity are the 33% of women receiving neoadjuvant systemic chemotherapy, which impacts nutritional status prior to surgical intervention. Currently, at our institution, this usually consists of gemcitabine and cisplatin or methotrexate, vinblastine, doxorubicin, and cisplatin regimens. Carboplatin is used in place of cisplatin for patients unable to receive cisplatin.

Our median operative time was 5.8 hours for women, which is comparable to the operative time for men; this time included anesthetic induction and reversal. Our median length of stay for women undergoing cystectomy is 8 days, reflecting our willingness to offer cystectomy to an often medically complex group of patients. Urinary diversion consisted of 63% ileal conduit, 35% orthotopic neobladder, and 2% cutaneous continent diversion, reflecting our continued use of orthotopic diversion in women.

COMPLICATIONS

Cystectomy remains a difficult operation in men or women, with a mortality rate of 1% to 3% (5,43,44). Twenty percent to 30% of patients will have a complication delaying discharge (44). Many of the specific complications after cystectomy are a consequence of the urinary diversion. Complications from the cystectomy portion include bleeding with subsequent coagulation abnormalities and rectal injury. Pelvic bleeding can be more difficult to control in women. Since 1995, the median blood loss in our female cohort has been 600 mL. A rectal injury should be extremely rare in women (due to the interposed vagina) and seen only in association with prior surgery or radiation therapy. The most frequent complications experienced in our female cystectomy series were urinary tract infection in 21%, prolonged ileus in 15%, wound infection in 8%, anemia requiring blood transfusion in 5%, clostridium difficile colitis in 5%, and intra-abdominal abscess in 3%. Thirty-day mortality was less than 1%.

The postoperative care after cystectomy requires a diligence over and above that seen with other urologic procedures. Some complications are preventable. A regimented, reproducible plan for the technique of cystectomy and diversion is enormously helpful to prevent errors during a 4- to 6-hour operation. Some complications are unavoidable, but recognition early in their evolution may drastically minimize the negative consequences, and a high index of suspicion is essential. Early recognition of a complication may prevent a cascade of other successive complications that may ultimately lead to increased morbidity or mortality (46).

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CHAPTER 21 BLADDER DIVERTICULECTOMY

SARAH FRAUMANN FARIS AND SAM S. CHANG

Bladder diverticula are the herniation of the bladder mucosa through the detrusor muscle fibers and are classified as either congenital or acquired. Congenital diverticula are postulated to be due to an inadequately developed or thin muscular wall, which is especially vulnerable near the intravesical ureter resulting in a common association with vesicoureteral reflux (1). Bladder diverticula are more common in males, typically present <10 years old and are often solitary and in smooth-walled bladders on cystoscopic examination. In contrast, acquired bladder diverticula are secondary to the elevated intravesical pressures generated as a result of bladder outlet obstruction. The most common causes of outlet obstruction include benign prostatic hyperplasia, urethral stricture disease, bladder neck contracture, posterior urethral valves, and neurogenic voiding dysfunction such as detrusor sphincter dyssynergia. They typically present in males >60 years old and are often multiple and found in association with bladder trabeculation (2).

Diverticula are typically located in the weakest points of the bladder including the ureteral hiatus (paraureteral or Hutch diverticulum) and both posterolateral walls (1–3). The diverticular wall is composed of mucosa, subepithelial connective tissue or lamina propria, occasional muscle fibers, and adventitial tissue, and at times, a fibrous capsule or pseudocapsule may be present (Figs. 21.1 and 21.2) (2,4).

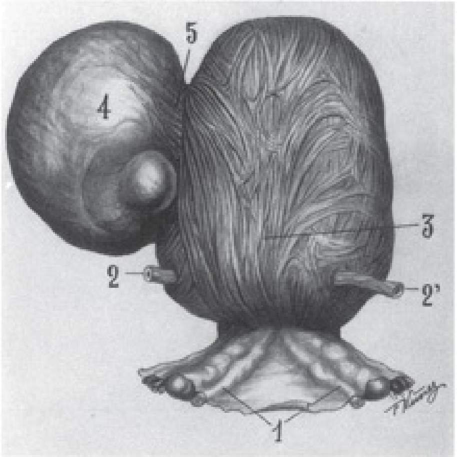

FIGURE 21.1 Posterior view of bladder and diverticulum: ampulla of vas deferens (*1*), ureters (*2* and *2'*), posterior longitudinal bundle of the outer layer of the detrusor (*3*), diverticulum (*4*), and circular fibers of the middle layer of the detrusor around the diverticular neck (*5*).

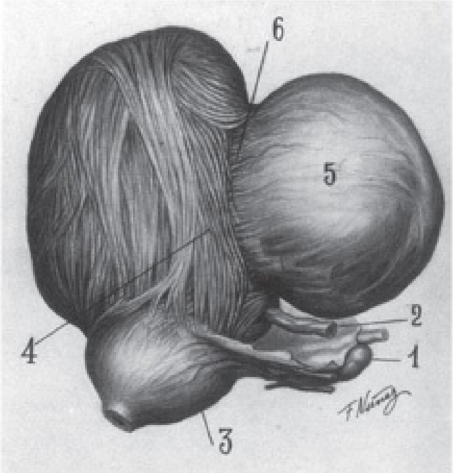

FIGURE 21.2 Lateral view of bladder and diverticulum: seminal vesical (*1*); ureter (*2*); prostate (*3*); anterolateral longitudinal fibers of the outer layer of the detrusor (*4*); diverticulum (*5*); and fine, circularly oriented fibers around the diverticular neck (*6*).

DIAGNOSIS

Acquired bladder diverticula are often asymptomatic and found during the workup for recurrent urinary tract infections, lower urinary tract symptoms, or hematuria. When signs and symptoms are present, they include irritative or obstructive voiding symptoms, pelvic pain or fullness, and hematuria. Urinary stasis often results in recurrent infections that can be difficult to eradicate and may also result in bladder stones. Bladder cancer can also develop in diverticula, and urine cytology should be considered. When evaluating for a bladder diverticula, the differential diagnosis includes urachal, prostatic utricle and müllerian duct cysts, ectopic ureteral insertion, and "pseudodiverticular" images observed in cystograms such as bladder ears, hourglass bladder, everting ureterocele, and vesicular hernias. Other less frequent congenital anomalies should also be considered, such as vesicourachal diverticulum, incomplete bladder duplication, and septation of the bladder (1,5).

Given the nonspecific nature of the presenting symptoms, diverticula are commonly diagnosed on radiographic imaging. Imaging provides important information regarding the number, location, size, and anatomy of the diverticula. A voiding cystourethrogram (VCUG) with lateral, oblique, and postvoid views provides information on the extent of the diverticulum, if there is associated vesicoureteral reflux and the degree of bladder emptying. Additionally, ultrasound, contrast-enhanced computerized tomography (CT) scan and magnetic resonance imaging (MRI) can be useful for the evaluation of associated masses or ureteral obstruction (Fig. 21.3).

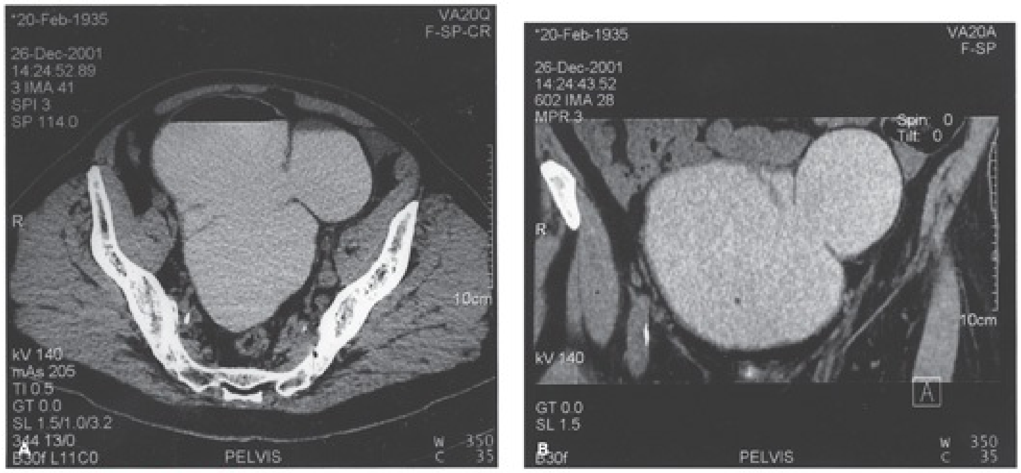

FIGURE 21.3 Contrast-enhanced CT scan demonstrating a large posteriorly based bladder diverticulum seen on (A) transverse and (B) sagittal images.

A video urodynamics study should be strongly considered to assess bladder anatomy, compliance, and contractility, and identify bladder outlet obstruction and neurogenic voiding dysfunction. It is important that underlying urologic abnormalities are addressed concurrently or prior to definitive surgical treatment of a bladder diverticulum. Prior treatment of the underlying etiology may result in resolution of the initial signs or symptoms, improve bladder emptying, and possibly render further surgical interventions unnecessary (2).

Cystourethroscopy should be performed to exclude urethral stricture disease and bladder neck contracture and rule out occult pathology such as a stone or carcinoma within the diverticulum (6). The entire surface of the diverticulum should be visualized, and the relative location of the ureteral orifices and bladder neck should be noted to assist in planning for any potential surgical procedure. Any suspicious mucosal lesions should be biopsied with extreme care taken to avoid bladder perforation.

INDICATIONS FOR SURGERY

All underlying urologic abnormalities should be addressed concomitantly or prior to definitive surgical treatment of a bladder diverticulum to prevent recurrence. Patients who have improved bladder emptying and symptomatology after relief of outlet obstruction can be managed expectantly with surveillance. In patients who have significantly impaired bladder contractility on preoperative urodynamics, persistently poor bladder emptying after relief of obstruction, or who are unable or unwilling to undergo surgical treatment of the bladder diverticulum, clean intermittent catheterization (CIC) or an indwelling catheter can be effective treatment options (2). In these patients, and in the absence of future complicating factors, surveillance of the bladder diverticulum with cystoscopy and urine cytology, and monitoring of the upper tracts with renal ultrasound and renal function, may be all that is required.

Indications for surgical intervention include chronic infections, stones, persistent symptoms, upper urinary tract deterioration from vesicoureteral reflux or obstruction, diverticular rupture, and malignancy (2). Additionally, we recommend simultaneous resection of all poorly emptying bladder diverticula to improve voiding if a patient is scheduled for an open prostatectomy, cystolithotomy, ureteroneocystostomy, or YV plasty of the bladder neck.

Malignancy has historically been reported in approximately 1% to 10% of diverticula; however, recent reports have found rates as high as 33% to 36% in clinically significant adult diverticula (6–8). Approximately 92% of these tumors are urothelial carcinoma, whereas 6% to 8% are squamous cell carcinomas, likely induced from chronic stasis of urine and infection. Additionally, compared to bladder carcinoma in general, there is an increased frequency of variant subtypes including squamous cell, neuroendocrine, adenocarcinoma, plasmacytoid, and signet ring cell and can be seen in approximately 25% of cases(7,8). Additionally, approximately 20% of patients will have coexisting intravesical urothelial carcinoma (7). Because of this potential malignant risk and the fact that these tumors can be difficult to diagnose, some have advocated prophylactic diverticulectomy. Alternatively, a more conservative strategy may be offered that includes surveillance cystoscopy and urinary cytology obtained at 6- to 12-month intervals.

ALTERNATIVE THERAPY

Many children with congenital diverticula who are asymptomatic and without urinary tract infections do not require therapy and a conservative approach has been advocated (1). Saccules and small diverticula may be treated successfully by transurethral electrocoagulation of their mucosa when the primary obstructive disease is endoscopically resolved. In addition, robotic-assisted, single-port, and laparoscopic approaches to bladder diverticulum may be effective as an alternative to open surgery with the distinct advantage of shortened convalescence time (9,10).

PREOPERATIVE ASSESSMENT

Aside from laparoscopic approaches, which are modifications of open techniques, there are two methods of surgical therapy: transurethral resection of the diverticular neck and open diverticulectomy. In either case, urine cultures should be obtained and infection must be adequately treated prior to surgery. If the lesion is acquired due to obstruction, the obstruction must be relieved prior to repair of the diverticula because this may obviate the need for additional surgical intervention and, if diverticulectomy is still necessary, prevent recurrence and subsequent treatment failure (2). If the diverticulum is due to high detrusor pressure of neurologic origin, this must also be addressed prior to surgical correction.

SURGICAL TECHNIQUE

Transurethral Resection

Endoscopic management may be a good option for elderly patients, poor open surgical candidates, or those with smaller diverticula that can be addressed at the time of transurethral resection of the prostate (2). Transurethral resection of the diverticular neck is a well-recognized treatment for small to midsized diverticula when the opening is not immediately impinging on the ureter (11). Using the standard resectoscope a Collins knife, loop or right-angle hooked electrode can be used to open the ostium of the diverticulum down to the muscular fibers of the bladder. This can be performed circumferentially and allows for subsequent inspection of the entire diverticular wall and facilitates drainage. Subsequent fulguration of the mucosa with a rollerball electrode can then be used to ablate the mucosa of the inner wall which can potentially obliterate the diverticulum or significantly reduce its size (2).

Caution must be exercised when tumor is present within a bladder diverticulum. Owing to the lack of muscular backing, transurethral resection of bladder tumors within a diverticulum carries a high risk of perforation. Cold-cup biopsy and fulguration may be appropriate for low-grade, low-stage tumors. The holmium laser may also be of use in this unique situation because it has a small fiber with a shallow depth of penetration (only 0.3 to 0.5 mm) and would certainly lower the risk of perforation or injury to adjacent structures. In those patients with high-grade or large diverticular carcinomas, particularly those with narrow ostium in which the risk of endoscopic perforation or inadequate resection is high, open diverticulectomy/partial cystectomy or total cystectomy has been advocated.

Open Surgical Technique

Open bladder diverticula excision has been described using three different approaches: extravesical, intravesical (also known as transvesical), and combined intravesical and extravesical. The most commonly used procedures and the points of technique that we use are described in the following sections.

For all procedures, the patient is placed supine on the operating table and the table flexed to aid with exposure. The external genitalia are then prepped into the sterile field. A Foley catheter is placed into the bladder on the surgical field to allow for passive drainage and active filling of the bladder as needed throughout the procedure. If the diverticulum is known to be in close proximity to ureters, ureteral stents should be considered to aid with dissection and avoid ureteral injury. If multiple diverticula are present, concomitant resection of all poorly draining diverticula is recommended.

The bladder is approached via an infraumbilical midline or transverse extraperitoneal incision, although alternatively a Gibson incision may be used. The linea alba of the rectus fascia is divided in the midline, and the rectus abdominis are spread apart. The transversalis fascia is then divided and the pelvis entered with care taken to avoid entry into the peritoneum. The dissection is carried into the space of Retzius and the anterior bladder wall and bladder neck are identified. After reflecting the peritoneum cephalad off the bladder dome, a self-retaining retractor can be placed to aid with exposure. Stay sutures are then placed in the detrusor at the dome and a vertical or horizontal cystotomy is performed. The self-retaining retractor can be adjusted and additional stay sutures placed as needed. The trigone, ureteral orifices, bladder neck and mucosa, and all possible diverticular orifices are clearly visualized. Ureteral catheters can be placed at this time if necessary.

In cases of intradiverticular tumor, some have advocated the instillation of 40 mg of mitomycin C by urethral catheter before the surgery. Intraoperatively, we carefully protect the surgical field with moist, sterile towels draped around the wound to avoid possible tumor contamination during diverticulectomy. The bladder mucosa should be thoroughly inspected to rule out papillary tumors that may have gone unnoticed on the previous endoscopic examination. The mouth of the diverticulum can also be packed with a small gauze pad to minimize potential tumor spillage.

Intravesical or Transvesical Diverticulectomy

For small diverticula <2.5 cm in diameter, we evert the diverticulum by gently grasping the bottom with an Allis- or Péan-type clamp inserted through the ostium and pulling it into the bladder. Careful inspection is then performed to ensure that adjacent structures have not been inadvertently pulled into the bladder due to adhesions to the diverticular wall. The mucosa of the diverticulum is then circumferentially divided at the diverticular neck using electrocautery and the diverticulum removed. The resulting vesicular defect is closed with 3-0 chromic catgut or Vicryl in two separate submucosal and muscular layers. In case of a saccule, a fine ligature of the neck and resection of its everted mucosa will suffice. If fibrosis secondary to infection is absent, the majority of small diverticula can be rapidly and easily removed using this technique.

If this maneuver is not feasible because of peridiverticular adhesions, we proceed to sharply divide the mucosa circumferentially around the diverticular orifice. The plane between the diverticular wall and surrounding fibrous pseudocapsule is identified. Gentle traction is then placed on the edges of the diverticular neck using Allis-type clamps. The external diverticular wall is carefully dissected free from the surrounding pseudocapsule in the periadventitial plane using a combination of blunt and sharp dissection and delivered into the bladder lumen. The bladder wall is then closed as previously mentioned (Fig. 21.4).

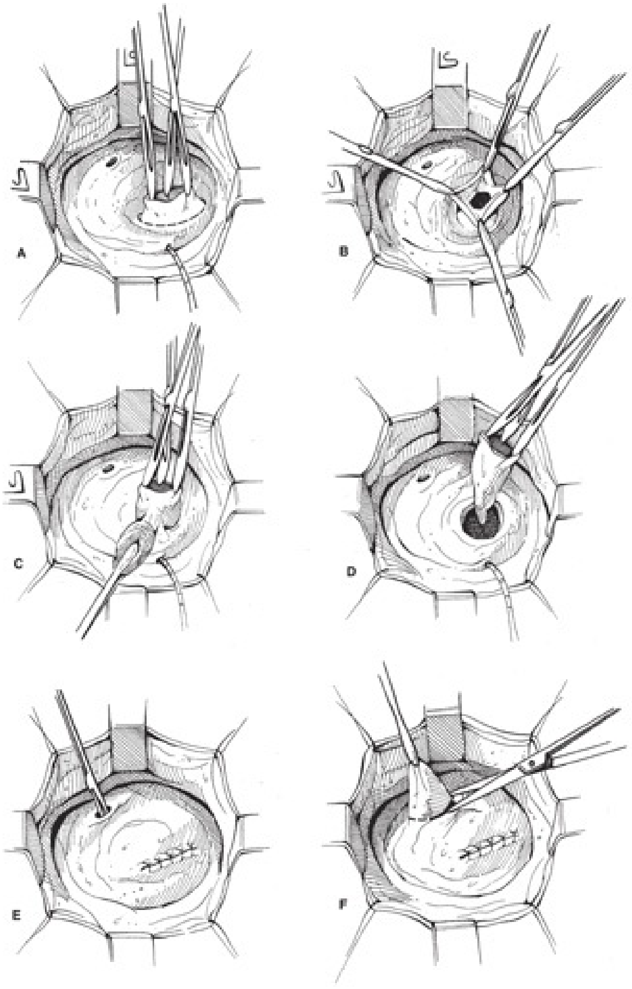

FIGURE 21.4 Technique of intravesical diverticulectomy. **A:** Diverticulum identified and (**B**) everted into the bladder. **C:** Inspection performed to ensure adjacent structures are not adherent to diverticular wall. **D:** Diverticular mucosa circumferentially divided at diverticular neck and diverticulum removed. **E:** Vesicular defect closed in two layers. **F:** Repeat as necessary.

Combined Intravesical and Extravesical Diverticulectomy

In patients with large diverticula or diverticula with significant peridiverticular inflammation, a combined intra- and extravesical approach is recommended. The bladder is opened and the diverticular ostium identified. Typically, a 7Fr or 8Fr ureteral catheter is placed into the ipsilateral ureter to aid with identification and to avoid inadvertent ureteral injury. Consider leaving an indwelling double-J ureteral stent for 2 to 3 weeks if the dissection is extensive. The surgeon can insert their index finger into the diverticulum bringing the neck outside of the bladder and assisting with the identification of the entire diverticulum. Alternatively, the diverticular sac can be filled with a moist gauze to unfold its wall and delimit its margins as accurately as possible. Overlying tissue is dissected free from the anterior bladder neck. The anterior neck of the diverticulum is then identified and incised extravesically with electrocautery (Figs. 21.5 and 21.6).

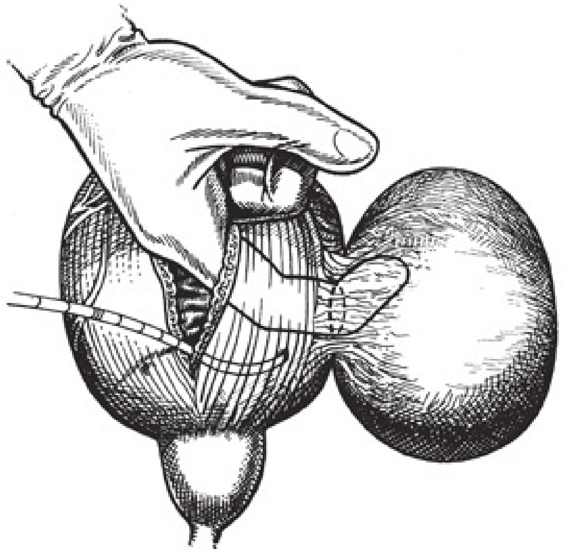

FIGURE 21.5 Procedure of combined intravesical–extravesical diverticulectomy. A finger is inserted into the bladder diverticulum from within the bladder.

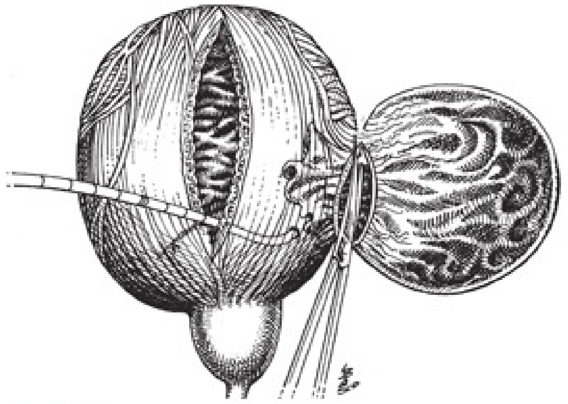

FIGURE 21.6 Procedure of combined intravesical–extravesical diverticulectomy. Once the diverticulum has been dissected, the mouth of the diverticulum is excised sharply.

Allis-type clamps are used for traction on the edges of the diverticulum, and the neck is circumferentially dissected from the bladder. The sac wall is then dissected from its surrounding pseudocapsule using a combination of sharp and blunt dissection. It is important to keep in mind that the ureteral course may have been distorted by the diverticulum, and the ureter may be closely adherent to the diverticular wall if repeated infectious processes have occurred. When extensive peridiverticular inflammation is present, it may be prudent to simply denude the diverticular mucosal lining with fine scissors or with the cutting current and the ball electrode from inside the diverticular cavity and then place a suction drain within it (first described by Pousson in 1901 and Geraghty in 1922).

The bladder wall and cystotomy are closed in two layers with absorbable 3-0 interrupted or continuous sutures and then the closure tested by filling the bladder. We leave a 10Fr closed suction drain in the space of Retzius and a urethral 18Fr or 20Fr Foley catheter, both of which may be removed after 5 or 6 days. For more extensive cases, those requiring large cystotomies, or in situations where there is prolonged drain output, the Foley catheter may be left in place for 10 to 14 days and a cystogram may be indicated prior to catheter removal.

OUTCOMES

Complications

The most serious complication of excision of a bladder diverticulum is an injury to the intramural or pelvic ureter during dissection. Placement of an ipsilateral ureteral catheter should help avoid this complication or aid in prompt recognition and repair. Small ureterotomies can be primarily repaired with absorbable 5-0 or 6-0 chromic or Vicryl and stented. If the distal ureter is severely damaged or completely severed, it is preferable to carry out ureteral reimplantation with or without a psoas hitch. More proximal injuries to the ureter may require a Boari flap or a transureteroureterostomy. End-to-end suture of ureteral edges is not recommended because there is a high likelihood that it will be complicated by urinary fistula or ureteral stenosis, which will further aggravate the situation.

Other potential complications include urinary fistula, urinary tract infection, bowel injury, and pelvic abscess. A less serious complication includes vesical urine leakage, which may cease spontaneously if the Foley catheter is maintained for additional days, providing the obstructive pathology has been resolved.

Results

Approximately one-third of bladder diverticulum are cured or significantly improved with transurethral resection. For benign disease, open excision is generally curative for that particular lesion, although correction of the underlying cause (e.g., outlet obstruction) is essential to prevent recurrence or the formation of additional diverticula. Historically, the prognosis of patients with carcinoma in the diverticula is generally poor. This has been attributed to the difficult and often delayed diagnosis and early escape from the confines of the bladder due to the lack of muscularis backing. However, more contemporary reports suggest relatively high 5-year survival rates of approximately 70%, attributed in part to earlier detection through improved radiographic imaging and a lower threshold for cystoscopy in the presence of hematuria, coupled with early aggressive surgical treatment (6,8). Nevertheless, due to the relative paucity of cases, treatment recommendations for these unique situations will continue to be based largely on patient characteristics and surgeon preferences.

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CHAPTER 22 BLADDER AUGMENTATION

STEPHEN MARK

Augmentation cystoplasty remains the surgical treatment of choice for the medically resistant neurogenic and nonneurogenic overactive bladder. The management goals are the provision of a low-pressure, large-volume storage reservoir typically emptied by clean intermittent catheterization (CIC) to provide renal preservation, continence, and a low risk of urinary tract infections (UTIs). Studies confirm a significant improvement in quality of life of patients and treatment with a durable outcome (1). Lifelong follow-up is required due to the high rate of complications and the potential need for reoperation. Concern for malignancy following bladder augmentation seems to have waned, and regular cystoscopic surveillance is not recommended. Future prospects of tissue engineering to provide an augmentation patch remain in evolution. Patients with incontinent urinary diversions like ileal conduits more frequently develop UTIs and upper tract deterioration compared to those with large, low-pressure reservoir employing the urethra as a continence method (2).

HISTORY

Augmentation cystoplasty was first described in 1888 in a canine model and first performed in 1889 in humans (3,4). The technique, however, only became popular in the 1950s for treatment of the contracted bladder from infections such as tuberculosis (TB) and schistosomiasis (5). The advent of CIC in the 1970s and an article by Bramble (6) further expanded the use of augmentation cystoplasty.

Over time, the bowel segment used for augmentation has expanded to include stomach (gastrocystoplasty), ileum (ileocystoplasty), cecum (cecocystoplasty), and sigmoid (colocystoplasty). Gastrocystoplasty is now contraindicated due to the greater risk of malignancy (7). Ileum remains the segment of bowel most preferred for augmentation on the basis of its availability, tissue mobility, and lowest rate of complication (8). Approximately 20 cm of terminal ileum is retained for its absorption function with a low long-term metabolic complication rate.

More recently, the number of augmentation cystoplasties has decreased (9). This reduction is due to a lower incidence of spina bifida, the long-term potential of malignancy, and an increase in alternative treatment options. Tissue engineering, despite a small clinical trial in humans, remains experimental (10).

PATIENT ASSESSMENT

The indications for augmentation cystoplasty remain the medically resistant overactive bladder from neuropathic and nonneuropathic origin. The four main groups of patients presenting for AC are congenital, idiopathic, inflammatory, and neuropathic in etiology (Table 22.1).

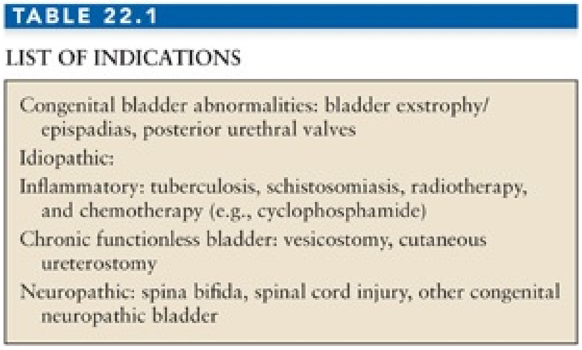

TABLE 22.1

LIST OF INDICATIONS

Congenital bladder abnormalities: bladder exstrophy/epispadias, posterior urethral valves

Idiopathic:

Inflammatory: tuberculosis, schistosomiasis, radiotherapy, and chemotherapy (e.g., cyclophosphamide)

Chronic functionless bladder: vesicostomy, cutaneous ureterostomy

Neuropathic: spina bifida, spinal cord injury, other congenital neuropathic bladder

Patients with congenital abnormalities present during surveillance after primary treatment with either risks of renal deterioration or persistent incontinence. The goals are a high-volume, low-pressure bladder with an ability to fully empty by CIC.

Patients with chronic inflammatory conditions need to have malignancy ruled out first by cystoscopic assessment and bladder biopsy.

Intractable incontinence from idiopathic detrusor overactivity is an indication for augmentation cystoplasty. In this group, the renal function is rarely at risk and treatment is aimed at managing incontinence. The initial treatments may include anticholinergic medication, sacral nerve stimulation therapy, botulinum toxin detrusor injection, and detrusor myomectomy (11,12). Postoperatively, a number of these patients can void efficiently but most require CIC, and it should be trialed preoperatively to confirm patient compliance.

In patients with a neuropathic bladder, the goals of management are renal preservation, continence, and protection against UTIs. These patients need to be intelligent, well-motivated, supported, have adequate hand function, and be able to undertake CIC. The majority of patients require CIC to empty their bladder to reduce the risk of UTI. Patients with progressive neurologic or cognitive diseases such as multiple sclerosis and/or dementia are poor candidates for augmentation cystoplasty because their ability to perform CIC may deteriorate with time. This makes them more dependent on caregivers for catheterization or a long-term catheter, which puts them at risk of recurrent UTIs. Those patients unable to catheterize because of their anatomy such as a wheelchair-bound female spina bifida patient should be considered for a continent catheterizable stoma (Mitrofanoff) along with an augmentation. Patients unable to self-catheterize because of their anatomy, motivation, hand function, or intelligence could lastly be considered for an incontinent urinary diversion. There is an integral role for continence nurse practitioners here to assess patients and families preoperatively and troubleshoot postoperative problems. These vital colleagues increase the patients' ability to remain independent and have good outcome.

In general, patients with significantly impaired renal function are a relative contraindication to augmentation cystoplasty because reabsorption of electrolytes can increase their risk of acidosis and further impairment of renal function. In a contrary view, however, augmentation cystoplasty may protect against further reduction in renal function and is useful in patients who require renal transplantation secondary to severe bladder dysfunction. Careful follow-up is required in this patient group to prevent dehydration, maintain regular bladder emptying to reduce the risk of acidosis, and acute medical problems.

Evaluation

The cornerstone of bladder assessment is video urodynamics. This assesses the bladder and the outlet and should confirm the decision to proceed with augmentation cystoplasty. The presence or absence of vesicoureteral reflux can be confirmed. However, reflux is typically a secondary phenomenon and is generally not surgically corrected with a ureteric reimplant (13). Reflux is usually corrected by increasing capacity and lowering the pressure of the bladder.

Assessment of the bladder outlet remains difficult. This is undertaken by incorporating patient history, renal function, and observation during urodynamics. The abdominal leak point pressure measures outlet resistance and suggests whether an outlet procedure should be undertaken with augmentation. Occasionally, urethral pressure profilometry and sphincter electromyography are used.

Bowel Segment Options

The bowel segments used depend on availability and the presence of any preexisting bowel disease (8). Ileum is the preferred bowel of choice after retaining 20 cm of terminal ileum for gut absorption. The expanding use of the appendix as a Malone antegrade continence enema (MACE) procedure for bowel management makes the cecum and terminal right ileum often somewhat adhered within the peritoneal cavity, reducing its mobility (14). Ileum is still used in the majority of these circumstances for augmentation, and if required, the MACE may be done synchronously or asynchronously with augmentation.

Gastrocystoplasty was increasingly used especially where short bowel syndrome is a potential consequence of further bowel segment removal and the bladder and the gastric wall seen as easier to tunnel a catheterizable channel through. More recently, this has reduced in popularity and is now contraindicated due to the increased risk of malignancy (7). The ileocecal region had been popular in the past, combining the terminal ileum and the cecum in an augmentation patch. This is not recommended due to increased risk of bowel dysfunction due to the loss of the ileocecal valve. The sigmoid colon has been used where small bowel will not easily mobilize into the pelvis. It is thicker walled and occasionally large and redundant in neuropaths where there is associated constipation.

Colocystoplasty has, however, been shown to have increased mucus production, a greater risk of urinary infection and a greater risk of complications requiring reoperation, and thus, it is a secondary choice for augmentation (15).

Ileum, as previously stated, remains the most popular bowel segment due to its mobility, lower production of mucus, and lower long-term complications.

ALTERNATIVE THERAPIES

More recently, several options have become available for the resistant overactive bladder. Botulinum toxin injections have been shown to be effective in both the neuropathic and nonneuropathic population. Given the low morbidity of this procedure, it can be tried prior to augmentation cystoplasty; however, its high cost and need for repeat injections are a barrier to widespread use, especially in younger patients (11). Sacral nerve stimulation has been used for refractory urge incontinence due to the nonneuropathic causes (12). It has not proven to be as popular due to the lower success rates and cumbersome implant.

Autoaugmentation of the bladder, also known as detrusor myomectomy, involves the excision of detrusor muscle over the dome and anterior wall of the bladder. This theoretically allows a diverticulum of epithelium to distend, thereby improving storage capacity and bladder compliance. This procedure is significantly less morbid, has the advantage of not incorporating mucus-producing bowel into the urinary tract, and almost uniformly allows patients to void spontaneously. Despite this, it has been less successful and it is not recommended in neuropathic patients (16). It has a small role in nonneuropathic patients who are younger with intractable urge incontinence especially associated with persistent nocturnal enuresis. Laparoscopic and robotic bladder augmentation has been reported, but this procedure is still investigational (17).

Other nonautologous tissue such as Teflon, Silastic, Gore-Tex, and bovine dura have been used for augmentation, but complications associated with bladder anastomosis, contracture, fistula, leakage, and stone formation have precluded their use (8). Tissue engineering is an innovative alternative. A small clinical trial has been reported in children with spina bifida. However, the short-term and long-term results have not been as promising. Clinical trial and experimental work are still under way to improve this novel alternative (10).

SURGICAL TECHNIQUE

The principles of augmentation cystoplasty are to enlarge the bladder with detubularized bowel segment, providing a high-capacity lower pressure reservoir. Twenty to 30 cm of detubularized ileum can be patched as U or straight patch. This bowel needs to be placed in the pelvis without tension and remain well vascularized. The bladder is split in the sagittal or coronal plane widely to reduce the risk of an hourglass diverticulum forming. Absorbable sutures are used in a single-layer anastomosis and suprapubic plus urethral or stoma catheter drainage is required postoperatively. The patient should be taught CIC prior to augmentation cystoplasty because the majority will need to do this for emptying. If a continent catheterizable channel is to be used, stoma position should be confirmed preoperatively. If the patients are to have a concurrent MACE procedure, the continent diversion channel should be placed on the left side or in the umbilicus.

No special bowel preparation is required with normal diet allowed up until the day before surgery with clear fluids on the day of surgery up until 2 to 6 hours preoperatively. Due to the low or absent bacterial count in the terminal ileum, no bowel preparation is recommended. Prophylactic intravenous antibiotics are routine especially in patients with a ventriculoperitoneal (V-P) shunt where this should be manipulated out of the operation site if becomes visible during surgery.

The patients are placed supine on the operating theatre table with a slight table break to allow better access to the pelvis (Fig. 22.1). A catheter is placed into the urinary tract and the bladder emptied immediately preoperatively. A midline incision may be extended above the umbilicus if necessary and a laparotomy performed. A self-retaining retractor, a ring, or Bookwalter-type retractor is useful to improve access. A Pfannenstiel incision is occasionally undertaken, but it may be difficult to get access to the peritoneal cavity to bring the ileum down especially in neuropaths where the terminal ileum may be prefixed due to the lumbar lordosis.

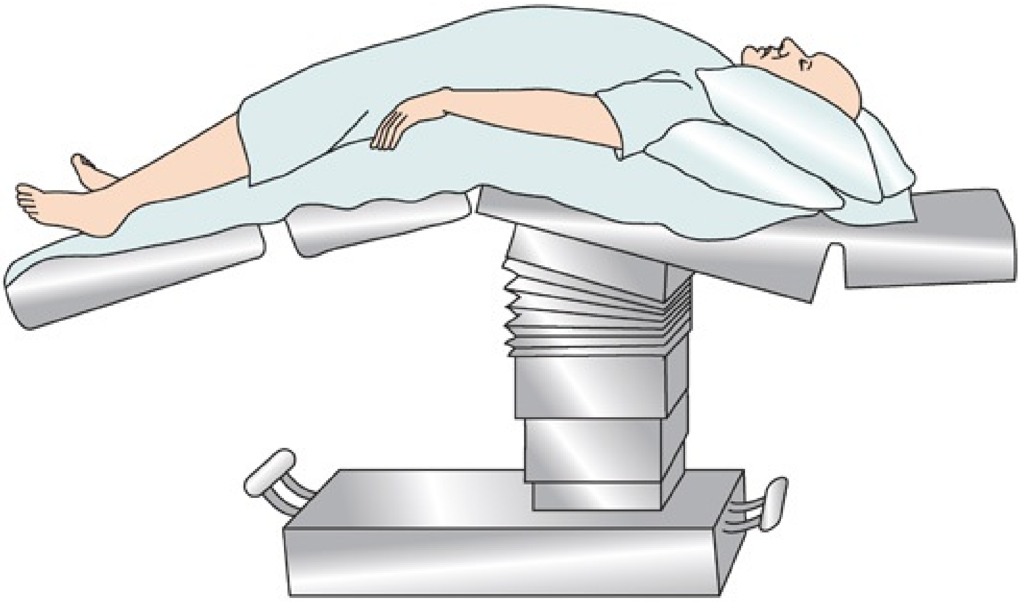

FIGURE 22.1 Patient position, supine with table extension to improve pelvic access.

Prior to harvesting a bowel segment or splitting the bladder, the bowel should be manipulated to the pelvis using Babcock or noncrushing clamps, just to make sure it is usable. Following laparotomy, the retropubic space is opened bluntly (Fig. 22.2). Stay sutures are placed at the dome of the bladder, and the bladder is split either in the sagittal or coronal plane (Fig. 22.3). Hemostasis is secured by diathermy, and the bladder incision is completed to within 1 to 2 cm of the intertrigonal bar and just above the bladder neck. Caution has to be undertaken around the site of the ureteric orifices, and if concerned, ureteric catheters can be placed for safety.

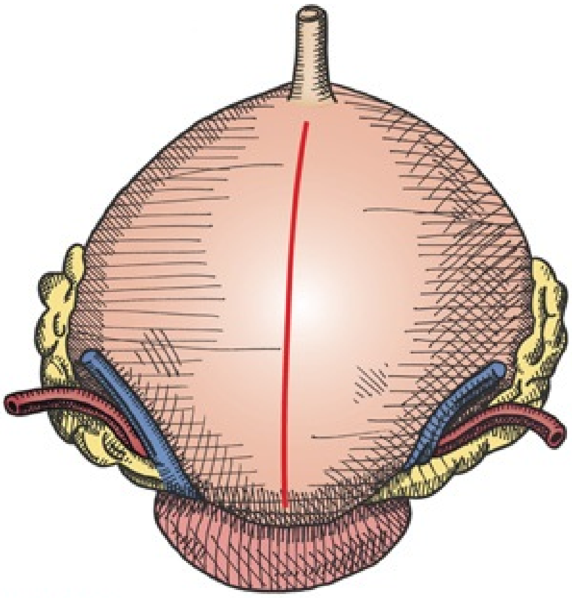

FIGURE 22.2 The peritoneum is dissected off the bladder which is incised in the saggital midline (Along the *red line*). The incision runs full thickness from just above the bladder neck, extended posteriorly to the level approximately 2 to 3 cm above the level of the ureters entering the bladder. This is facilitated by stay sutures placed at the bladder dome.

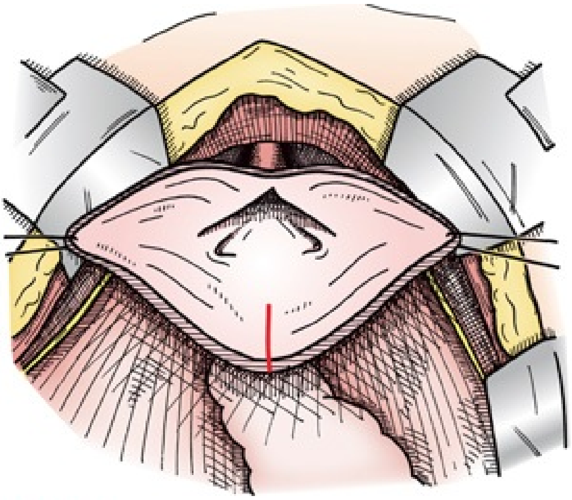

FIGURE 22.3 Bivalved bladder in sagittal plane to just above intertrigonal bar.

A bowel segment is selected approximately 20 cm from the terminal ileum, retaining two mesenteric vessels for blood supply (Fig. 22.4). The vascular pedicles through the mesentery can be divided by bipolar diathermy devices or suture division to allow this small bowel segment to be isolated on its vascular pedicle and remain well vascularized being brought into the pelvis. The bowel is divided between two noncrushing clamps and a bowel anastomosis performed. Increasingly, staples are used for the bowel anastomosis due to their speed; however, a single layer of absorbable sutures is more cost-effective. The mesentery may be left open or closed with interrupted or continuous sutures.

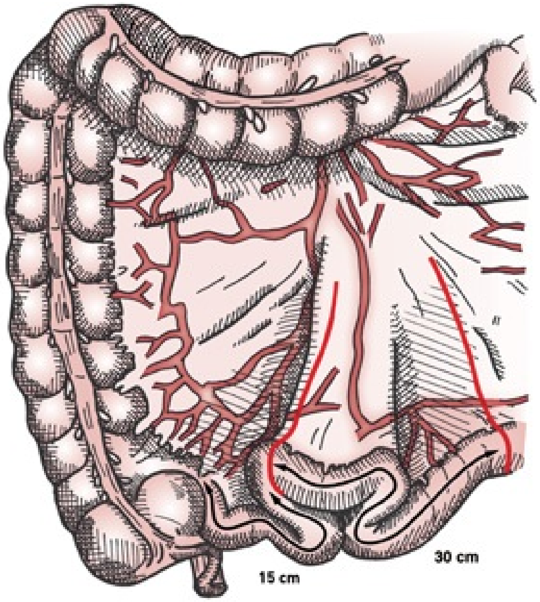

FIGURE 22.4 Approximately 15–20cm proximal to the ileocecal valve, a approximately 25–30cm segment of bowel is selected, the mesentery cleared, and the segment removed using standard techniques. The *red lines* indicate the division of the small bowel mesentry leaving a good blood supply to the ileal augment segment. *Double arrows* are identifying lumen and could be removed as add little.

The bowel is detubularized along its antimesenteric border and either constructed into a U loop or used as a single linear segment (Fig. 22.5). An alternative is to divide the bowel close to the posterior mesenteric surface to create an asymmetric segment of detubularized bowel and creating a U loop so that the vascular pedicle remains more posterior and the thin bowel wall anterior (Figs. 22.6 to 22.9). This allows extra mobility for the augmentation patch to reach the pelvis without tension. Continuous one-layer absorbable suture is used for the anastomosis between the augmenting bowel and bladder, beginning at the posterior aspect (Figs. 22.10 to 22.13). A suprapubic catheter can be placed and sutured to the peritoneal wall on the anterior surface to reduce the risk of a urine leak postoperatively and assist with bladder washouts (Fig. 22.14).

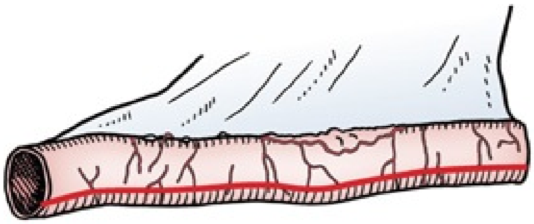

FIGURE 22.5 The ileum is opened along the antimesenteric border.

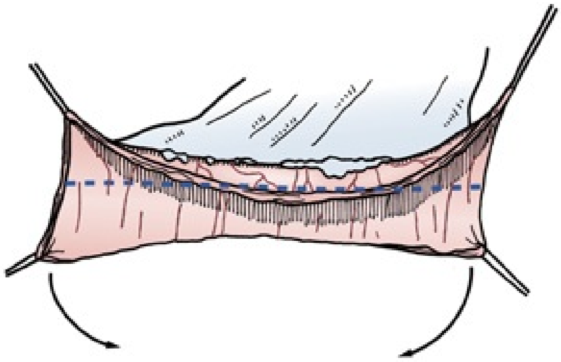

FIGURE 22.6 The ileum is mobilized toward the pelvis and posterior aspect opposed to create a U-shaped augmentation patch. The *dotted line* represents the location of the mesentry on the outer aspect of the ileum. The *curved arrows* indicate the movement of the bowle patch to create a U shaped patch.

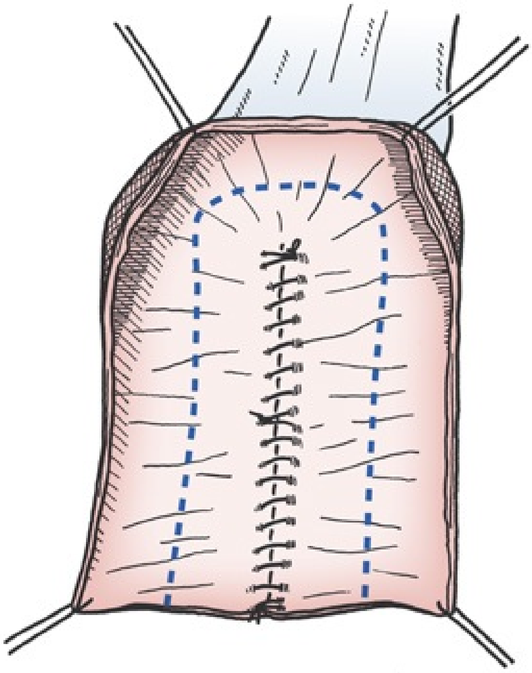

FIGURE 22.7 The posterior wall of the augment is completely closed. The *dotted broken line* indicates the position of the mesentry on the serosal surface.

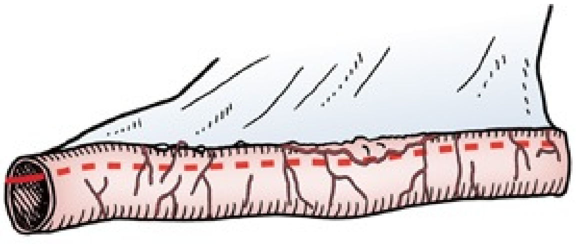

FIGURE 22.8 Alternative technique with incision to detubularize bowel placed more posteriorly to provide a longer anterior bowel flap. This modified technique facilitates a tension-free bladder anastomosis at times where the distance between the ileum and mesentery is greater. The *dotted red line* indicates the position of the bowel incision on the posterior aspect of the small bowel, near the mesenteric attachment.

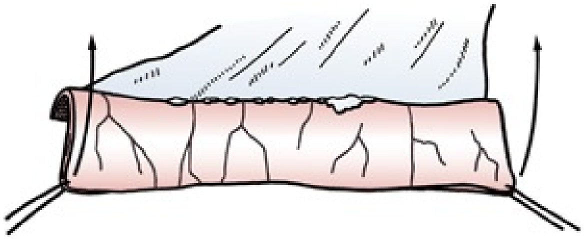

FIGURE 22.9 Larger augmentation bowel flap elevated to allow posterior closure into a cup shape. The *curved arrows* indicate the rotation of the bowel segment upward to give a longer portion of bowel anteriorly.

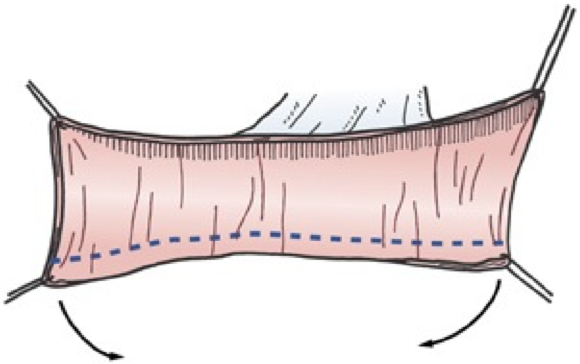

FIGURE 22.10 Bowel flap rotated posteriorly. The *dotted line* represents the location of the mesentery on the outer aspect of the ileum. The *curved arrows* indicate the direction the bowel is rotated to provide a cup shaped patch.

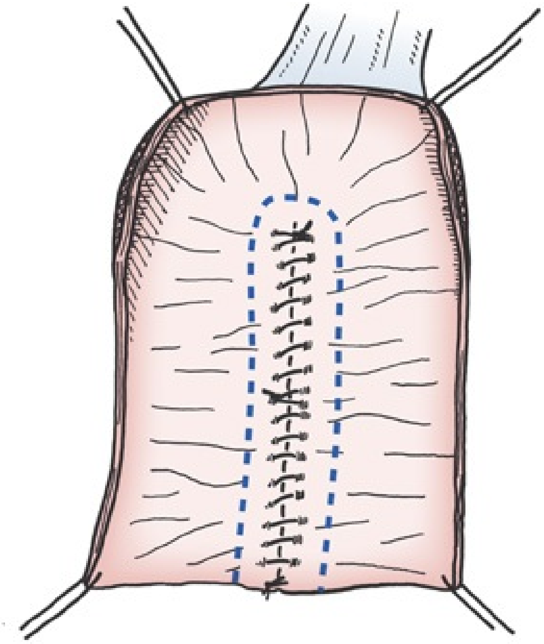

FIGURE 22.11 The posterior wall of the augment is completely closed. The *dotted line* represents the location of the mesentery on the outer aspect of the ileum.

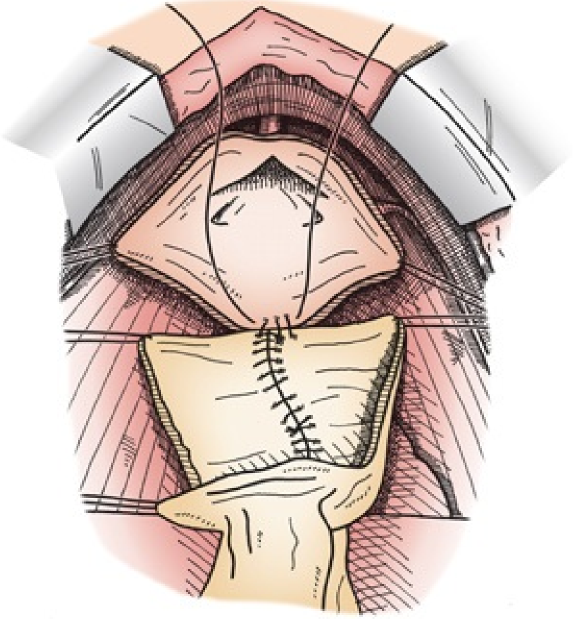

FIGURE 22.12 Initial suture placement for enterocystoplasty. Note this starts in the midline posteriorly with two running absorbable sutures.

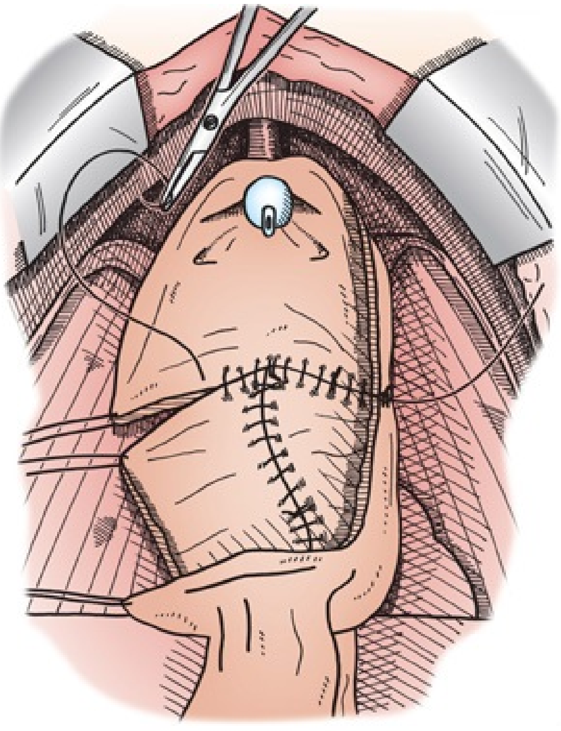

FIGURE 22.13 Closure of the posterior aspect of the enterocystoplasty. Note placement of the urethral catheter for postoperative urine drainage.

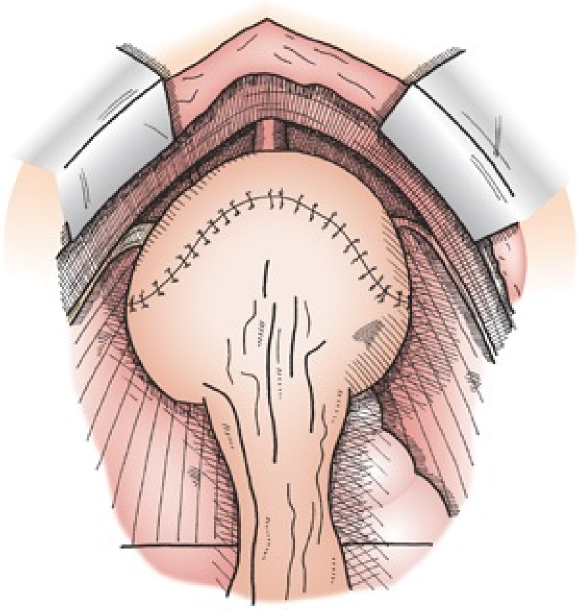

FIGURE 22.14 View of the completed enterocystoplasty. Note placement of urethral and suprapubic catheter for double drainage of urine. A drain is placed in the retropubic place and the wound closed in standard fashion.

If an outlet procedure is required to increase urethral resistance for continence, it should be undertaken synchronously (18). This can be by a procedure to increase static resistance such as a bladder neck sling or a dynamic device insertion such as an artificial urinary sphincter. There is a relative contraindication to placing such a prosthetic device after opening the small bowel; however, the risk of infection is low. Bladder neck closure is undertaken rarely at the same time as augmentation.

Dissection around the bladder neck for appropriate placement of a bladder neck sling can be undertaken more easily when the bladder is opened and urethral catheter visible within the lumen. Slings can be rectus fascia, skin or synthetic in nature, and tensioned to increased outlet resistance. Bladder neck closure is rarely required but can be facilitated with a two-layer closure interposing some vascularized tissue at the same time to reduce fistula formation.

If a continent catheterizable urinary diversion is planned, the stoma siting should be decided and marked preoperatively, and the patient counseled regarding catheterization. Often, the appendix has been used in a MACE procedure, and thus, this channel is not available for a Mitrofanoff type procedure. A Monti-type tube can be constructed using small bowel (19). The Monti tube is generally constructed over a 12Fr catheter sutured in place and can allow a form of drainage postoperatively to provide double drainage initially. The most proximal small bowel segment facilitates placement of the catheterizable channel on the left side of the abdomen. Tunnelling of the catheterizable channel in a ratio of 1:4 lumen diameter to tunnel distance is best undertaken through the thickened native bladder wall. If a catheterizable channel is planned, the bladder wall split can be placed in an eccentric fashion more toward the right side, creating a larger left-sided bladder wall plate. This anatomic modification minimizes tissue tension, provides a short straight channel, and improves the chances of a good outcome.

Catheter drainage from a channel exiting the umbilicus is also popular. In some series, this technique has been shown to have a higher incidence of stone formation possibly due to the less efficient drainage due to a higher catheterization channel in the abdominal wall. The catheterizable channel can have its skin site hidden via a rotation skin flap technique to facilitate cosmesis and improve body wall image.

Following augmentation cystoplasty plus or minus an outlet procedure, the peritoneal cavity is generally washed out and drains placed into the pelvic and peritoneal site. A suprapubic catheter plus stomal/urethral catheter is used for drainage. Complete wound closure with absorbable sutures and subcuticular skin sutures or staples is used.

Postoperatively, intravenous fluids maintain hydration and oral intake is commonly delayed until the ileus resolves. Intravenous antibiotics are generally continued for 48 hours, only if a V-P shunt is in place. The bladder is double drained with a suprapubic and stomal or urethral catheter and generally irrigated intermittently in the first 48 hours to reduce mucous obstruction. Clean intermittent catheterization is begun 2 to 4 weeks postoperatively, and the suprapubic catheter is removed when this is efficient. Clean intermittent catheterization is initially at regular intervals, occasionally waking at night to minimize overfilling. Daily irrigation reduces the risk of mucus-based stone formation and should be continued long term. Antibiotic prophylaxis may be undertaken at the time of intermittent catheterization but is not recommended long term.

Follow-up regimens vary. However, initial renal function and serum bicarbonate are monitored regularly. A renal ultrasound (US) is recommended annually both for surveillance of the kidneys and to determine if stone formation occurs. Vitamin B_{12} follow-up is generally not recommended for the first 5 to 10 years but may be integrated as part of long-term follow-up after that.

A pre- and postoperative protocol is provided in Table 22.2. The protocol can be modified if the results are abnormal according to clinical need.

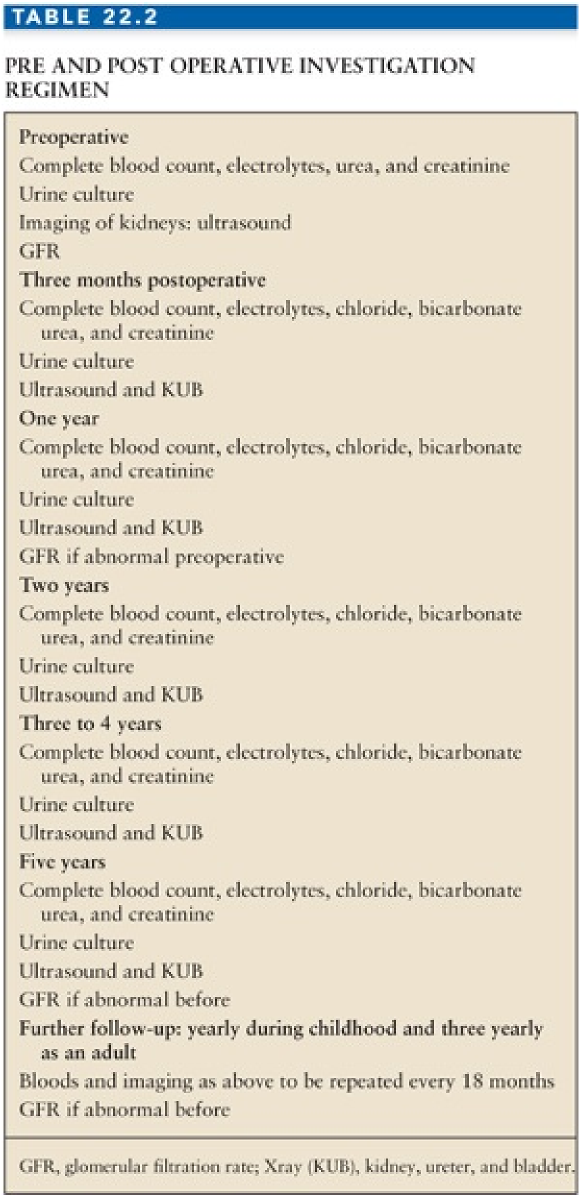

TABLE 22.2

PRE AND POST OPERATIVE INVESTIGATION REGIMEN

Preoperative
Complete blood count, electrolytes, urea, and creatinine
Urine culture
Imaging of kidneys: ultrasound
GFR
Three months postoperative
Complete blood count, electrolytes, chloride, bicarbonate urea, and creatinine
Urine culture
Ultrasound and KUB
One year
Complete blood count, electrolytes, chloride, bicarbonate urea, and creatinine
Urine culture
Ultrasound and KUB
GFR if abnormal preoperative
Two years
Complete blood count, electrolytes, chloride, bicarbonate urea, and creatinine
Urine culture
Ultrasound and KUB
Three to 4 years
Complete blood count, electrolytes, chloride, bicarbonate urea, and creatinine
Urine culture
Ultrasound and KUB
Five years
Complete blood count, electrolytes, chloride, bicarbonate urea, and creatinine
Urine culture
Ultrasound and KUB
GFR if abnormal before
Further follow-up: yearly during childhood and three yearly as an adult
Bloods and imaging as above to be repeated every 18 months
GFR if abnormal before

GFR, glomerular filtration rate; Xray (KUB), kidney, ureter, and bladder.

OUTCOME

The outcome of ileal augmentation cystoplasty is generally very good, improving quality of life, preserving renal function, and improving continence (1,13,15). UTIs are a risk, and if occur, a review of technique and completeness of CIC is useful.

Generally, outcomes are best when patients undergo augmentation cystoplasty for the correct indication have good preoperative education, the correct surgery is undertaken, and postoperative care carefully instituted. This has been increasingly overseen by continence nurse practitioners. They are also called on to review catheterization difficulties, oversee independence of patients within the community, and re-present to a clinic environment for troubleshooting problems if issues have occurred. These continence nurses have become integral in the successful management of these complex patients.

COMPLICATIONS

Complications can be categorized as early and late. The incidence of complications overall is 28% early and 44% late. Up to 30% of patients required reoperation (20). Early complications include those affecting the bowel, urinary tract, and wound. Bowel complications include persistent ileus, bowel obstruction, and bowel leak (6% to 9%). Sepsis, especially involving a V-P shunt is rare. Wound infections are commonly seen in up to 6% of patients (15). Early urinary tract complications include sepsis, leakage, and obstruction (5% to 15%). Suction drains are placed postoperatively, and if a urine leak occurs, the drains are taken off suction and regular flushing of the urinary catheters continues to allow draining of the urine. Commonly clear fluid drains from the peritoneal cavity and, in the setting of V-P shunt, could potentially be cerebrospinal fluid. Mucous obstruction is not uncommon, early and regular flushing of both the suprapubic catheter and stomal/urethral catheter can reduce the incidence. Subsequently, patients are taught to flush their urinary diversion daily or if there is mucous obstruction.

Late complications again can be divided into those related to the bowel, the urinary tract, and renal function. Bowel complications are commonly due to mechanical obstruction from adhesions, which occurs in up to 9% of patients (20). Diarrhea, which can be difficult to control especially in some neuropathic patients, is due to loss of the ileocecal valve and/or an incompetent anal sphincter (21). Malabsorption syndromes such as low vitamin B_{12} leading to megaloblastic anemia are rare (22).

Renal function requires observation over time as does acid-base balance. Metabolic acidosis is uncommon if patients are selected properly and bladder emptying is regular and complete. Screening should be undertaken for this postoperatively and treatment with oral bicarbonate is usually successful.

Long-term urinary tract complications are more common. Recurrence of a “hostile” bladder with high pressure and low capacity is rare but occasionally occurs and presents with either continence issues or renal tract dilation (23). Occasionally, reaugmentation is required, but initially, conservative measures with anticholinergics, intravesical anticholinergics, or botulinum toxin can be tried. Urinary incontinence which occurs either from the outlet or a catheterizable channel usually requires reoperative surgery. Catheterization difficulties can be due to stenosis or angulation of the Monti channel or appendix. Skin stenosis is not uncommon requiring occasional dilatation, stomal plugs, or reoperative surgical procedures. Prevention of these complications is generally by proper patient selection and careful intraoperative technique.

UTIs are commonly seen in 4% to 43% of patients (24). It is useful to divide these between simple lower tract infections and pyelonephritis with a risk of sepsis. Microbiology confirms the organism, but care needs to be taken to separate asymptomatic bacteriuria from a UTI. Renal US and kidney, ureter, and bladder Xray (KUB) can determine if there are anatomic risks for recurrent UTI, and subsequent management is typically dependent on these investigations. Prophylactic oral antibiotics are not routinely recommended except potentially in patients with renal transplant. If there is no anatomic cause for UTI, careful focus on CIC technique is helpful in making sure complete emptying is undertaken.

Bladder stones are often seen in between 25% and 50% of patients and typically related to hydration and bladder irrigation (20). They are seen more commonly following colocystoplasty due to higher mucus production. Bladder stones often present with hematuria, incontinence and recurrent lower UTIs, or on routine surveillance. Renal US and KUB will identify the stones. Treatment can either be endoscopic, laparoscopic, or open, depending on stone size and number.

Spontaneous bladder perforation is a feared complication with significant mortality. The patient may have few presenting symptoms and signs but rapidly develop sepsis (25). A combination of poor emptying (a full bladder), a competent bladder outlet with blunt abdominal trauma, sometimes quite minimal can cause rupture. Clinical suspicion should be high, and a computerized tomography cystogram is the investigation of choice. Early laparotomy and repair plus drainage is standard; however, some cases can be managed conservatively with drainage, antibiotics, and careful observation (26).

Malignancy risk has been anecdotally overestimated, and studies suggest patients with intermittent catheterization and those with neuropathic bladders have slightly higher malignancy risk than the general population (7,27). With ileocystoplasty, it is not recommended that routine surveillance is undertaken for malignancy by cystoscopic assessment or urine cytology. Gross hematuria is a strong indicator of pathology and mandates routine investigations. Gastrocystoplasty and patients with augmentations for inflammatory conditions such as TB need regular cystoscopy due to higher malignancy risk (2% to 10%) (28,29).

SPECIAL CIRCUMSTANCES

Complex reconstructions in the urinary tract also have some special situations worth mentioning. These include transitional care from pediatric to adult health care, pregnancy, and renal transplant.

Transitional care has evolved as a dilemma for patients who have complex urologic conditions transferring their care from pediatric urologists and institutions to adult urologists and adult institutions. With the advent of pediatric urology as a subspecialty and the separation of institutions, this process has gained increasing concern as to potential gaps in this complex patient's care. Where institutions are combined (adult and pediatric), this transition appears easier. If transition is poorly managed, patients have a high risk of social and medical complications. There is some evidence to suggest variable age of transition based on patient maturity, availability of appropriate services, and adult urologists to undertake and oversee care improves transition outcome.

Pregnancy and augmentation cystoplasty is more commonly seen. Urologic consultation is recommended during pregnancy, but a normal vaginal delivery appears safe. Vaginal delivery is not recommended where patients have an artificial urinary sphincter in situ (30). If cesarean section is required, urologic presence is to reduce the risk of complications. A classic cesarean section through a transperitoneal wound is recommended. The mesentery of the augmentation is often pushed sideways from the gravid uterus, and under direct vision, cesarean section can be undertaken. The bladder should be drained preoperatively and left to drain for at least 48 hours postoperatively and appears safe when done in conjunction with a urologist.

The timing of augmentation cystoplasty in patients with chronic renal impairment awaiting transplant is controversial (31,32). There are risks and benefits for the augmentation being undertaken before, at the same time, and after renal transplant. If renal transplant is organizable as with a living donor, augmentation cystoplasty can be undertaken electively 4 to 6 weeks prior to the transplant, with bladder cycling performed prior to the renal transplant. Subsequently, the transplant is undertaken with the transplanted ureter anastomosed into the augmented bladder. The outcome of renal transplant in an augmented bladder appears to be similar to that of a renal transplant in a patient with a normal bladder.

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CHAPTER 23 MANAGEMENT OF THE DISTAL URETER FOR NEPHROURETERECTOMY

GAVIN N. WAGENHEIM AND SURENA F. MATIN

The standard therapy for upper tract urothelial cell carcinoma of the renal pelvis or ureter is radical nephroureterectomy, with en bloc resection of the ureter and a cuff of bladder around the ureteral orifice. When performed using open surgery, this multiquadrant operation requires a long midline incision or two incisions for the nephrectomy in the upper retroperitoneum and the distal ureterectomy and bladder cuff resection deep in the pelvis. Because of the potential morbidity associated with this operation, alternative approaches such as the “pluck” and “intussusception” techniques were devised. Other modifications include transvesical and extravesical approaches to resect the distal ureter and bladder cuff; the extravesical approach can be done with or without opening the bladder. Using the extravesical approach without opening the bladder may avoid patient repositioning, but this approach violates the golden rule of excising the distal bladder cuff under direct vision, which is the only method of confirming complete excision. Transvesical and endoscopic approaches allow for excision of the cuff under direct vision but usually require patient repositioning and thus increase the operative time (1).

Laparoscopic nephroureterectomy has been shown to further reduce morbidity by eliminating the flank incision for the renal portion of the procedure, thus allowing for decreased postoperative analgesic use, reduced hospital stays, and more rapid convalescence (2). The development of robotic-assisted techniques has also driven attempts to decrease operative times, blood loss, and length of hospital stays (3). These less invasive approaches offer some advantages in reducing the intensity and duration of convalescence. However, because intact extraction of the specimen is recommended after laparoscopic nephroureterectomy (owing to the importance of pathologic staging and the propensity for urothelial carcinoma to implant into wounds), an open surgical approach to the distal ureterectomy may not necessarily require a much larger incision than would be required for the nephrectomy portion of the procedure.

DIAGNOSIS

The most common presenting symptom or sign of upper tract urothelial tumors is hematuria, which occurs in 56% to 98% of patients, and the second most common symptom or sign is flank pain present in approximately 30% of patients (4–6). The subsequent evaluation entails an upper tract imaging study with intravenous urography, computerized tomography, magnetic resonance imaging, or retrograde pyelography. Most patients have a filling defect that suggests an upper tract urothelial tumor. Whether both sides of the urinary system need to be evaluated with retrograde studies, selective cytology, or ureteroscopy, owing to the small chance of a bilateral tumor, depends on the individual practitioner. In general, if good-quality imaging does not show any abnormalities on the contralateral side and an obvious mass appears on one side, additional evaluation of the normal-appearing side is not necessary.

All patients require evaluation of the bladder given the highly similar biology of bladder and upper tract urothelial carcinoma. At this time, retrograde studies, selective cytology, and ureteroscopic evaluation may also be performed. Selective upper tract cytology has been shown to improve the diagnosis of upper tract urothelial carcinoma. The accuracy of detection of high-grade lesions, including carcinoma in situ, is nearly 80%, and this has definite prognostic value (7). Direct ureteroscopic evaluation and biopsy are also important aspects of the evaluation because the additional information is critical for risk stratification. The tumor architecture has been shown in multiple studies to have independent prognostic value; sessile tumors are more often associated with a high pathologic stage than papillary tumors (8). Biopsy results showing high-grade tumors are also associated with high-stage disease at least 65% of the time (9).

The combination of positive voided or selective cytologic findings with a radiographic abnormality consistent with an upper tract urothelial tumor may be considered adequate for diagnosis if nephroureterectomy is intended. However, this practice does not allow for complete clinical risk stratification to determine whether the patient may benefit from multimodal therapy prior to surgery. Given the significant loss of renal function following nephroureterectomy, many patients may not be eligible for postoperative chemotherapy if they are found to have high-stage disease (10). For patients in whom neoadjuvant chemotherapy is not indicated, positive cytologic findings combined with a radiographic abnormality may be sufficient to proceed with nephroureterectomy. If voided cytologic findings are positive, bladder biopsies are necessary to rule out bladder disease, and selective washings can be performed. Patients with positive selective cytologic findings and negative bladder and prostatic urethral biopsies but no identifiable lesion on the ureteroscopic image represent a diagnostic dilemma. Many practitioners consider this set of findings to be diagnostic of carcinoma in situ of the upper tract and treat with nephroureterectomy or topical therapy. Other practitioners recommend that these patients be followed closely rather than undergo nephroureterectomy without a definitive diagnosis.

Once urothelial malignancy is diagnosed, metastatic evaluation consists of abdominal and pelvic computerized tomography and chest imaging with radiography or computerized tomography. A bone scan is performed if the patient has bone pain, elevated alkaline phosphatase or serum calcium levels, or bony abnormalities appearing on other imaging studies. However, owing to lack of bone turnover in cases of bony metastases, a bone scan may be falsely negative. A complete blood count, serum electrolyte analysis with creatinine, and liver function tests should also be performed. If the estimated glomerular filtration rate is reduced (<60 mL per minute per 1.73 m^2), a renal scan to determine differential function may aid in decision making.

Patients found to have regional lymphadenopathy will not be cured with surgery alone and will experience systemic recurrence within a short time period. Thus, similar to patients with bladder cancer, these patients should undergo chemotherapy as the primary mode of treatment (11). Those who have an excellent response to chemotherapy may be considered for salvage surgery to include regional lymphadenectomy.

All treatment options, including the possibility of lymphadenectomy, should be discussed with the patient. The treatment plan must take into account prognostic variables that may be used to select patients for neoadjuvant systemic therapy, and patients should be counseled properly on the potentially increased likelihood of recurrence if advanced disease is found in the pathologic analysis. Clinical variables that affect the likelihood of recurrence include biopsy tumor grade, tumor architecture, the presence of hydronephrosis, and imaging findings suspicious for advanced disease. Clinical risk stratification is more important in upper tract urothelial malignancies than in bladder cancer, owing to the challenges and significant limitations of performing accurate clinical staging in the upper tract. Two preoperative nomograms that use a combination of the previously described factors can be used for more accurate clinical risk stratification and patient counseling for those with upper tract malignancy (8,12). For example, a patient whose biopsy findings show a high-grade sessile tumor has at least an 80% chance of having advanced disease in the final pathologic evaluation (8).

INDICATIONS FOR SURGERY

Nephroureterectomy

Radical nephroureterectomy with excision of the distal ureter and bladder cuff is the standard therapy for upper tract urothelial tumors. This procedure uses open, laparoscopic (standard or hand-assisted), or robotic-assisted surgical techniques. Several approaches to the distal ureter have been described, and there is no agreement on the ideal technique for distal ureter and bladder cuff excision (13,14). Radical nephroureterectomy with en bloc resection of the distal ureter, intramural tunnel, ipsilateral ureteral orifice, and bladder cuff is required for adequate management of upper tract urothelial carcinoma. This should be performed with controlled occlusion of the ureter or ureteral orifice. The risk of recurrence in ureteral stumps or periureteral meatus is 30% to 64% (14). Excision of this segment is critical because approximately 70% of ureteral tumors are found in the distal ureter (15). Thus, when choosing a method to dissect the distal ureter and bladder cuff, the surgeon must be aware of the presence and location of all tumors.

Lymphadenectomy

Radical lymphadenectomy in patients with bladder cancer has been shown to improve staging and prognosis (16). The effects of standard and radical lymphadenectomy on patient outcomes are still under investigation. However, recent studies have identified improved cancer-specific survival durations in patients with high-stage (pT3+) and high-grade (G3+) urothelial carcinoma of the upper urinary tract who underwent radical lymphadenectomy. Importantly, lymphadenectomy for low-stage cancer (pT2 or less) was not found to lead to the same improvement in cancer-specific survival (17). This highlights the importance of preoperative staging to guide the treatment plan.

Nodal involvement rates for tumors located in the renal pelvis, upper ureter, and midureter range from 20% to 30%. The nodal involvement rate for distal ureteral tumors is lower, approximately 10%. It has been suggested that tumors originating in the renal pelvis or proximal two-thirds of the ureter should be treated with radical nephroureterectomy as well as wide retroperitoneal lymph node dissection. This should include the hilar, paracaval, and retrocaval nodes on the right and the renal hilar and para-aortic lymph nodes on the left. Tumors located within the distal two-thirds of the ureter may be adequately treated with pelvic lymph node dissection, including the common, external, and internal iliac lymph nodes as well as the obturator nodes (18) (Fig. 23.1).

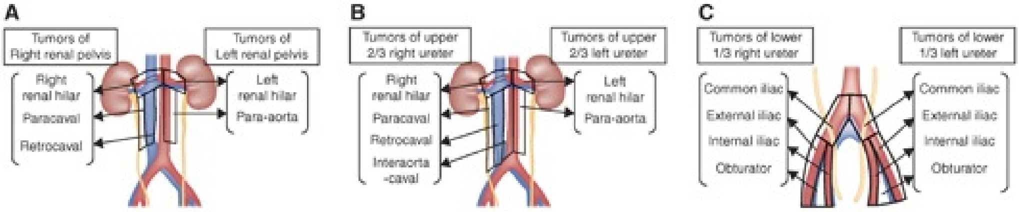

FIGURE 23.1 Regional lymph node schema according to primary tumor location. (Adapted with permission from Kondo T, Nakazawa H, Ito F, et al. Primary site and incidence of lymph node metastases in urothelial carcinoma of upper urinary tract. *Urology* 2007;69(2):265–269. Copyright © 2007 Elsevier Inc. All rights reserved.)

KIDNEY-SPARING THERAPY

Endoscopic resection and fulguration are acceptable for patients with low-grade, low-stage, and small tumor burdens. An alternative for a distal ureteral tumor is a distal ureterectomy with a ureteroneocystostomy or other reconstruction. Segmental resection and primary ureteroureterostomy may be considered in rare cases of tumors in the proximal ureter, and partial nephrectomy may be considered for even rare cases of isolated polar tumors with imperative indications; partial nephrectomy is rarely indicated (19). After complete endoscopic control or distal ureterectomy, adjuvant topical therapy with bacille Calmette-Guérin (BCG) or mitomycin C may be attempted to prevent recurrence, although the benefits of this strategy are not completely clear. For patients with urothelial carcinoma in situ, BCG topical therapy is considered primary therapy and the outcomes in this group appear to be similar to those with bladder carcinoma in situ in a limited experience (20).

SURGICAL TECHNIQUE

As can be seen by the myriad of options available, no single “standard” method to resect the distal ureter and bladder cuff has been determined, attesting to the challenge of aligning anatomy with disease management. Unofficially, most experts agree that either a formal intravesical approach (requiring clamshell incision of the bladder) or an extravesical approach with a formal bladder cuff is their primary technique. Some of the other techniques in the following sections have been associated with an increased risk of positive margins or have the potential for compromises in oncologic management. The authors suggest that the following factors are central tenets of surgical technique that should be adhered to regardless of the technique performed:

- Evaluation of the distal ureter for the presence or absence of tumors if alternative methods of management are considered
- Taking wide soft tissue margins around the ureter where disease is located; if disease has occurred at the intramural ureter, an en bloc partial cystectomy may be needed.
- Avoiding uncontrolled spillage of any fluid possibly containing cancer cells
- Visual confirmation of complete resection of the ureteral orifice and bladder cuff

Specific to this chapter, the last tenet is inarguably the single most critical point and the one that is most commonly compromised in practice.

Open Surgical Techniques

Intravesical Approach

Open surgical distal ureterectomy can be used in conjunction with any technique of nephrectomy.

After completing the nephrectomy and proximal ureteral dissection, place the patient in the supine position, with or without flexion of the table. Insert a three-way 20Fr urethral catheter into the bladder. Make a lower midline incision, divide the rectus fascia, develop the space of Retzius, and place a self-retaining retractor. Fill the bladder with saline and then open it longitudinally between two stay sutures, preventing and actively suctioning any fluid spillage. Place additional stay sutures at the apices of the bladder incision. Pack the dome of the bladder with a gauze sponge, and use a bladder blade to retract the bladder dome cephalad. Insert a ureteral catheter or feeding tube into the targeted ureteral orifice and sew it in place with a 4-0 suture. Use electrocautery cutting current to incise the mucosa no more than 1 cm around the ureteral orifice. Dissect the intramural ureter using tenotomy scissors and pinpoint electrocautery (Fig. 23.2).

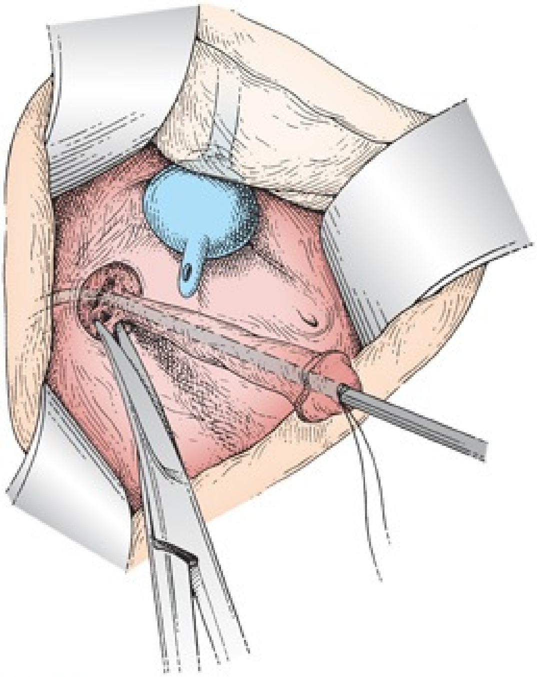

FIGURE 23.2 A ureteral catheter is secured to the ureteral orifice. Tenotomy scissors and electrocautery are used to dissect the intramural ureter. (Reprinted with permission from Lange PH. Carcinoma of the renal pelvis and ureter. In: Glenn JF, ed. *Urologic Surgery*, 4th ed. Philadelphia: JB Lippincott Co, 1991:273; used with permission.)

Dissect the entire distal ureter free to join the point of previous dissection completed during the nephrectomy portion of the procedure. Close the posterior bladder wall in two layers (2-0 absorbable sutures for the serosa and muscle and 4-0 absorbable sutures for the mucosa), and close the anterior bladder incision similarly. Insert a pelvic drain through a separate stab incision. Leave the urethral catheter in place for 3 to 5 days. Some practitioners use cystography to ensure that the bladder has healed prior to removing the catheter, whereas others remove the catheter and perform a voiding trial.

At times, the dissection of the distal ureter may be difficult and the ureter may need to be dissected extravesically as well. This may require division of the superior vesical artery and the entire lateral pedicle of the bladder to provide adequate access to the distal ureter.

Extravesical Approach with or without a Formal Bladder Cuff

A completely extravesical approach is best performed through a Gibson incision. After entering the retroperitoneal space and identifying the distal ureter, retract the bladder to the contralateral side. With this approach, division of the superior vesical artery and the entire lateral pedicle is crucial to facilitate dissection of the entire distal ureter. Identify the ureteral hiatus and dissect the intramural ureter using electrocautery. Cephalad traction on the ureter helps identify the bladder mucosa, but be careful not to tear the ureter. At this point, two options exist. The first and completely extravesical approach is to use a right-angle clamp to secure the ureteral orifice and then excise the ureter. Tie a 2-0 absorbable suture around the right-angle clamp to close the bladder mucosa, or use a running 4-0 absorbable suture. Close a second layer over the resection site using 2-0 absorbable sutures. The second option, which is more preferred by the authors, is to perform a formal resection of the bladder cuff by incising the mucosa and visually confirming complete resection of the ureteral orifice with the cuff. Place a stay suture on the apex of the cystotomy prior to complete resection of the ureter. Once the ureter and cuff are excised, close the incision in two layers as previously described. Manage drains and catheters as previously described.

Laparoscopic Extravesical Bladder Cuff Technique (21)

This technique is similar to the open surgical extravesical approach. Place the patient in a modified flank position for transperitoneal laparoscopic nephrectomy. Using flexible cystoscopy, insert a ureteral catheter. At the conclusion of the laparoscopic nephrectomy, dissect the ureter distally and place clips on the ureter to prevent extravasation of tumor cells. Retract the ureter cephalad and continue dissecting it distally to the bladder. After inserting a 10-mm port in the lower abdomen to facilitate resection of the distal ureter, incise the bladder just anterior to the ureter using electrocautery. Upon entering the bladder, the ureteral catheter identifies the ureteral orifice. Excise the posterior portion of the bladder cuff and detach the ureter after dividing the ureteral catheter. Suture the bladder closed using freehand laparoscopic suturing or other techniques. Manage drains and catheters as previously described.

Robotic-Assisted Techniques

Transvesical Approach (22)

With this technique, robotic assistance is used after laparoscopic management of the kidney. The robotic assistance portion includes the distal ureterectomy and bladder cuff resection, and the patient must be repositioned for these procedures. After dissecting the kidney and proximal ureter, occlude the ureter with a Hem-O-Lok clip or ligating suture. Place a fourth port on the contralateral side, in a line between the umbilicus and iliac crest. Place the patient in a steep Trendelenburg position and dock the robot using the three inferior port sites.

Next, distend the bladder and make a transverse incision along the posterior margin of the dome (Fig. 23.3). Identify the previously placed ureteral stent and place a stay suture through the stent and the ureteral orifice for retraction. Score the bladder circumferentially and dissect through the detrusor muscle. Free the final attachments extravesically (Fig. 23.4). Close the ureteral orifice defect from within the bladder in two layers, and close the incision in the dome extravesically in two layers. Extend the ipsilateral, lower abdominal port site to a Gibson incision to allow extraction of the specimen. Manage drains and catheter as previously described.

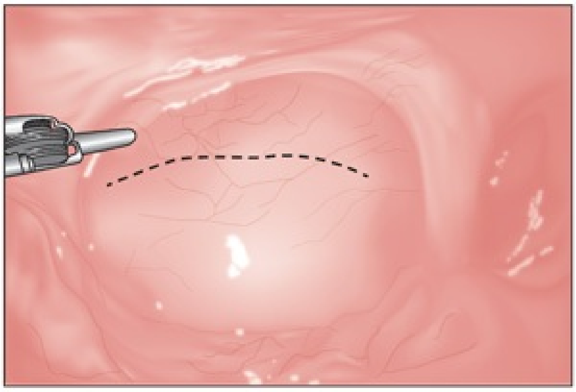

FIGURE 23.3 The *broken line* represents the location of the transverse incision in the posterior dome of the bladder.

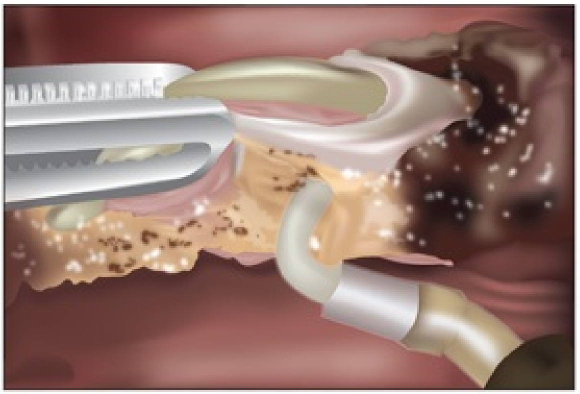

FIGURE 23.4 Ureteral attachments are freed extravesically.

Extravesical Approach with a Formal Bladder Cuff (3)

Place the patient in a modified flank position, disease side up, slight Trendelenburg, with the table flexed. For the procedure, place the camera port lateral to the rectus sheath and about 7 to 8 cm below the most cranial robotic port, which should be placed at the juncture of the lateral rectus and costal margin. Place the other two robotic ports inferior to the camera port, one 7 to 8 cm caudal and lateral to the camera port, which is about 2 to 3 cm lateral and cranial to the superior iliac spine, and the other 15 to 16 cm caudal to the camera port, which places it a few centimeters above the pubic bone. Dock the robot at an angle over the hip to facilitate angulation of the arms into the pelvis (Fig. 23.5).

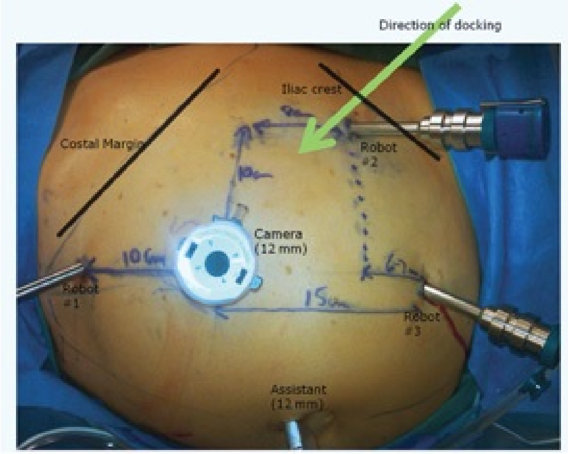

FIGURE 23.5 Ports and docking are shown for robotic-assisted nephroureterectomy for the extravesical approach with a formal bladder cuff. (Copyright © 2012 S.F. Matin.)

After dissecting the kidney, controlling the vasculature, and occluding the ureter, rearrange the instruments and use the caudal port as the retracting arm, the lateral port as the right arm, and the cranial port as the left arm. As before, with this approach, it is critical that the superior vesical artery and entire lateral pedicle of the bladder are ligated and divided to allow proper identification and full dissection of the entire ureter. The space of Retzius on this side also must be developed to allow rotation of the bladder medially. Dissect the ureter distally to the ureterovesicular junction. Distension of the bladder aids in identification of this landmark. Expose the detrusor to ensure an adequate margin for resection. Empty the bladder to prepare for cuff excision. After creating a cystotomy medial to the ureter and visually confirming a complete cuff, place a stay suture to prevent retraction. Use the retracting robot arm to retract the ureter or stay sutures cranially and excise the bladder cuff (Fig. 23.6). Then close the bladder in a running two-layer fashion with an absorbable suture. The Foley catheter should then typically be irrigated to ensure a watertight closure. Extract the specimen periumbilically or by extending one of the port sites. Manage drains and catheters as previously described.

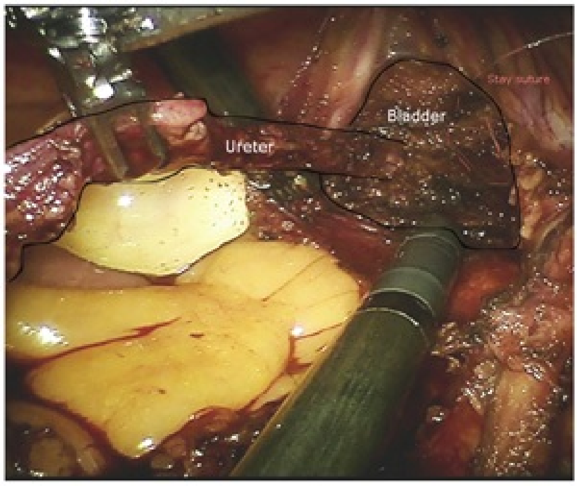

FIGURE 23.6 Excision of the bladder cuff using the ureter for cranial retraction is shown. (Copyright © 2012 S.F. Matin.)

Endoscopic Techniques

Except for the "pluck" procedures, all of the endoscopic techniques described in this section have been developed specifically for use in conjunction with laparoscopic nephroureterectomy. The techniques are described in the following sections in the settings in which they were initially described or are in common use at this time. The hand-assisted approach to laparoscopic nephroureterectomy may be preferable with particular techniques, as indicated in the following sections, but any approach to nephroureterectomy—laparoscopic or open surgical—can be used in conjunction with any of the following techniques, with modifications, as long as oncologic principles are maintained.

Transvesical Bladder Cuff Technique: Single Port (23)

After completing a nephrectomy with the patient in the modified flank position, dissect the ureter to the bladder. Place clips on the ureter to prevent tumor spillage.

Without repositioning the patient, fill the bladder with fluid through a three-way urethral catheter. Make an incision for a 10-mm laparoscopic port in the midline, three fingerbreadths above the pubis. Using the surgeon's hand via the hand-assist port, push the bladder upward toward the abdominal wall. Insert a spinal needle through the incision into the bladder to ascertain the proper angle and depth of entry, and then insert a 10-mm laparoscopic port directly into the bladder through the extraperitoneal space. Using a 24Fr resectoscope with a Collins knife through this port, and with the surgeon's hand alternately elevating the ipsilateral hemitrigone and retracting the ureter, incise around the ureteral orifice and intramural ureter with the Collins knife (Fig. 23.7). During the resection, controlling the height of the urethral catheter drainage bag controls the filling of the bladder. As soon as the ureter is detached, placing the drainage bag on the floor minimizes extravasation of urine and irrigant. Note that once the bladder has been opened into the retroperitoneum, it collapses quickly, so take care to keep the dissection at equal depth all around the orifice so that once the bladder collapses, the ureter can be pulled free easily.

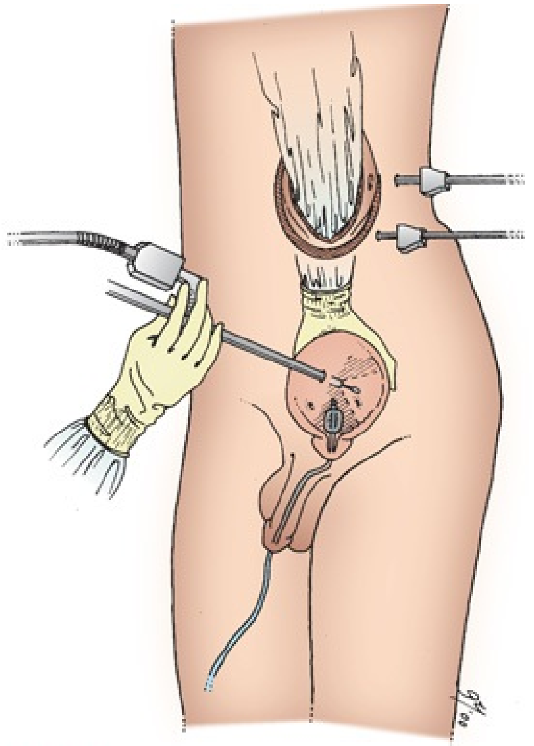

FIGURE 23.7 The surgeon's hand elevates the ipsilateral hemitrigone while the Collins knife is used to incise around the ureteral orifice. (Adapted with permission from Gonzalez CM, Batler RA, Schoor RA, et al. A novel endoscopic approach towards resection of the distal ureter with surrounding bladder cuff during hand assisted laparoscopic nephroureterectomy. *J Urol* 2001;165:484. Copyright © 2001 American Urological Association, Inc. Published by Elsevier Inc. All rights reserved.)

After specimen removal, remove the bladder port. Neither the port site nor the resection site needs to be closed, but placement of a pelvic drain through a laparoscopic port site is optional. The initial description of this technique includes cystography performed on postoperative day 7 to verify lack of extravasation prior to catheter removal, but in the authors' experience with this technique, the cystotomy is adequately healed by this time and a voiding trial is sufficient.

Transvesical Bladder Cuff Technique: Two Ports (24)

Prior to performing the nephrectomy portion of the procedure, place the patient in the lithotomy position. Perform cystoscopy to evaluate the bladder mucosa and distend the bladder. Under cystoscopic guidance, place two 5-mm balloon-tipped laparoscopic ports into the bladder just above the pubic bone on both sides of the midline, setting both ports to wall suction to prevent extravasation and overdistention of the bladder. Insert a 5-mm endoloop through the ipsilateral port, and then insert a 6Fr ureteral catheter cystoscopically into the targeted ureter. Exchange the cystoscope for a resectoscope with a Collins knife, which is used to incise around the ureteral orifice. Using a grasper inserted through the other laparoscopic port that is passed through the endoloop, retract the ureteral orifice anteriorly. After freeing up 3 to 4 cm of ureter, suspend the ureter from the anterior bladder wall with the grasper (Fig. 23.8); then, remove the ureteral catheter and tighten the endoloop around the ureter to occlude the lumen.

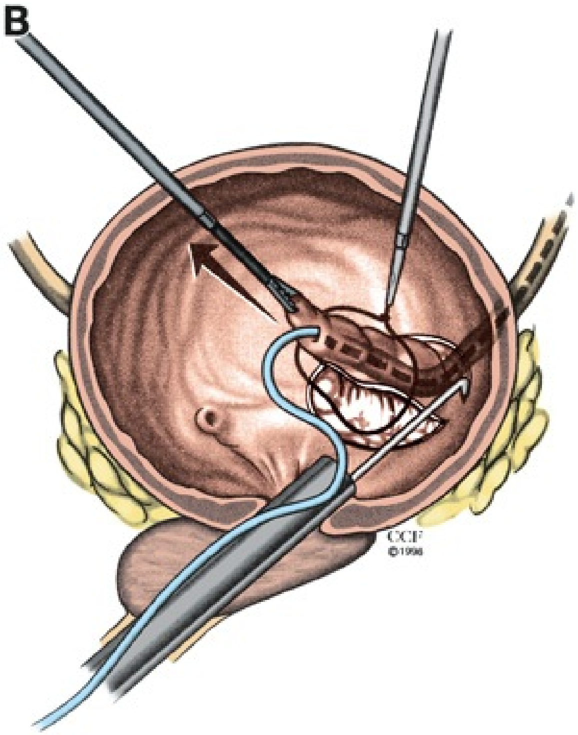

FIGURE 23.8 The Collins knife is used transurethrally while a grasper elevates the ureter and the endoloop is around the resected orifice. (Adapted from Gill IS, Soble JJ, Miller SD, et al. A novel technique for the management of the en bloc bladder cuff and distal ureter during laparoscopic nephroureterectomy. *J Urol* 1999;161:432. Copyright © 1999 American Urological Association, Inc. Published by Elsevier Inc. All rights reserved.)

After removing the laparoscopic ports, set a urethral catheter to gravity drainage. Perform the nephrectomy portion of the procedure after repositioning the patient, and with cephalad traction, dissect the ureter distally such that the distal ureter can be pulled into the operative space for intact removal. Again, a urethral catheter is left in place for 1 week, with the option of cystography to confirm adequate bladder healing prior to catheter removal.

Transurethral Bladder Cuff Technique

This technique is similar to the transvesical bladder cuff technique except that the resection is performed transurethrally, which obviates the need for placement of a transvesical port. One option is to use a flexible cystoscope with an electrocautery probe to perform the periureteral dissection (25). Another alternative is to position the patient in a combined lithotomy-semiflank position that allows simultaneous laparoscopic nephrectomy and transurethral access with a 24Fr resectoscope with a Collins knife (26).

Ureteral Unroofing Technique (27)

Prior to performing the nephrectomy portion of the procedure, place the patient in the lithotomy position. Perform cystoscopy and insert a ureteral dilating balloon (5-mm diameter, 10-cm length) into the targeted intramural ureter. Inflate the balloon to 1-atm pressure with dilute contrast material using fluoroscopic guidance. Exchange the cystoscope for a resectoscope with a Collins knife, and incise the ureteral tunnel at the 12 o’clock position along the entire length of the intramural ureter. Remove the dilating balloon and use a rollerball electrode to cauterize the edges and floor of the intramural ureter. Insert a 7Fr 11.5-mm balloon occlusion catheter into the renal pelvis and inflate it at the ureteropelvic junction to prevent urine extravasation. Connect this catheter, and a urethral catheter, to gravity drainage.

Take the patient out of the lithotomy position and perform the nephrectomy. Once this is completed, mobilize the distal ureter to the ureteral hiatus, dividing the superior vesical artery if necessary. Ligate and incise the remaining distal ureter and bladder cuff using an endoscopic stapler (Fig. 23.9), removing the ureteral balloon occlusion catheter just prior to engaging the stapler. Leave the urethral catheter in place for 3 to 5 days, removing it after cystography or a voiding trial demonstrates no urinary extravasation. A modification of the technique, which allows for nephrectomy to be performed before ureterectomy, is to manage the distal ureter with a stapler as described earlier and then reposition the patient into the lithotomy position. Use a resectoscope and a rollerball to ablate the intramural ureter until the staple line is visible.

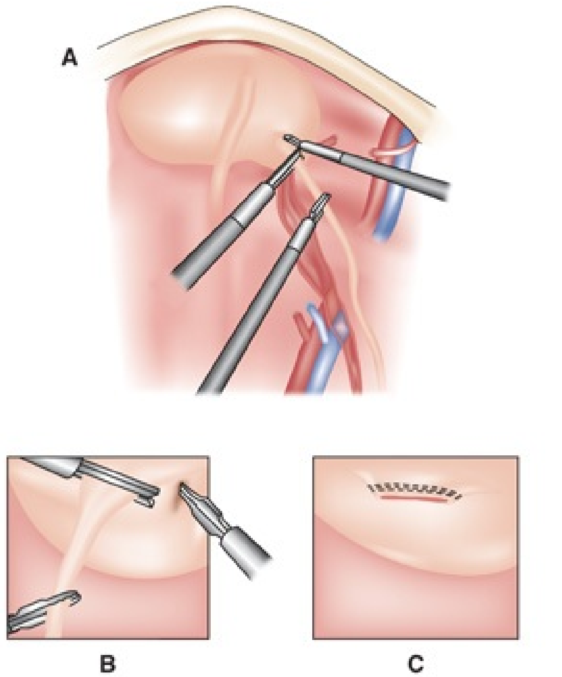

FIGURE 23.9 A: The endoscopic stapler is placed across the ureterovesical junction. B: Close-up view of the stapler across the ureterovesical junction. C: Staples are seen securing the bladder cuff.

Pluck Technique

Place the patient in the lithotomy position prior to performing the nephrectomy. Insert a ureteral catheter into the targeted ureteral orifice cystoscopically. Incise the ureteral orifice and surrounding bladder cuff with a Collins knife to the level of retroperitoneal fat. Alternatively, use a loop resectoscope to resect the orifice and intramural ureter. Set a 24Fr urethral catheter to gravity drainage. Take the patient out of the lithotomy position and perform the nephrectomy. Dissect the ureter distally and, with cephalad traction on the ureter, detach it from the bladder. Leave the urethral catheter in place for 7 days, removing it after cystography or a voiding trial.

A modification of this technique is to pass a 7Fr, 11.5-mm balloon occlusion catheter into the renal pelvis, snugging it down at the ureteropelvic junction, to minimize urine extravasation. Mitomycin can be instilled into the renal pelvis through this catheter (28).

Of note, a proper transurethral resection using the pluck technique will expose the extravesical space, and multiple case reports have documented tumor seeding associated with the pluck technique (29–31). The authors include this technical description for historical purposes but do not recommend its use.

Combined Open and Endoscopic Technique: Ureteral Intussusception (Stripping) (32)

Initially, with the patient in the lithotomy position, insert either a stone basket or ureteral catheter into the targeted proximal ureter. Reposition the patient and perform nephrectomy, dissecting the ureter to the pelvic brim. Clip the proximal ureter and then divide the ureter cephalad to the basket/ureteral catheter. Advance the stone basket into the retroperitoneum and open and close it to entrap the ureteral wall, or, if a ureteral catheter has been used, tie it to the ureter with a 0 silk suture (Fig. 23.10). Apply gentle traction to the stone basket/ureteral catheter to intussuscept the ureter into the bladder (Fig. 23.11). Then, use a Collins knife mounted on a resectoscope inserted transurethrally (after repositioning the patient into the lithotomy position) to incise the bladder cuff out of the urethra around the intussuscepted ureter while exerting traction on the stone basket/ureteral catheter.

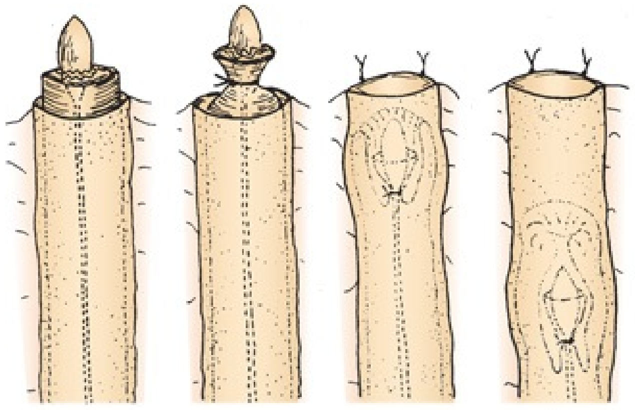

FIGURE 23.10 The proximal ureter is divided and secured to the ureteral catheter. The ureter is then intussuscepted as the catheter is removed. (Adapted from Angulo JC, Hontoria J, Sanchez-Chapado M. One incision nephroureterectomy endoscopically assisted by transurethral stripping. *Urology* 1998;52:204. Copyright © 1998 Elsevier Science Inc. All rights reserved.)

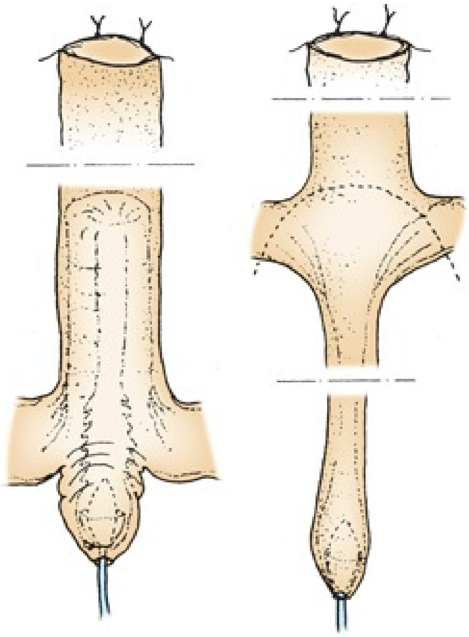

FIGURE 23.11 The catheter is retracted through the bladder wall and urethra. (Adapted from Angulo JC, Hontoria J, Sanchez-Chapado M. One incision nephroureterectomy endoscopically assisted by transurethral stripping. *Urology* 1998;52:204. Copyright © 1998 Elsevier Science Inc. All rights reserved.)

Place a urethral catheter for a minimum of 7 days, which can be removed after a normal cystogram or voiding trial. This technique should not be used for distal or midureteral tumors.

OUTCOMES

Survival durations and the probability of tumor recurrence associated with upper tract urothelial carcinoma are strongly driven by tumor stage. However, outcomes are also influenced by tumor grade, architecture, presence of lymphovascular invasion, and lymph node status. Radical nephroureterectomy is associated with a 5-year recurrence-free survival rate of 69%, and a 5-year cancer-specific survival rate of 73%. Importantly, patients with noninvasive (<pT1) upper tract urothelial carcinoma have been shown to have a 5-year recurrence-free survival rate of 95% and a 5-year cancer-specific survival rate of 96% (13).

Whether the method of managing the distal ureter and bladder cuff is linked with outcomes is not yet fully clear, owing to the strong influence of tumor factors and selection bias from retrospective studies. Although they are based on retrospective data, recent publications have shown no differences in recurrence-free, cancer-specific, or overall survival durations among the extravesical, intravesical, and transurethral approaches to the management of the distal ureter. Current data report 5-year recurrence-free survival rates of 66% for transvesical, 66% for extravesical, and 69% for endoscopic approaches. Similarly, data have shown 5-year cancer-specific survival rates of 71% for transvesical, 70% for extravesical, and 82% for endoscopic approaches and 5-year overall survival rates of 66% for transvesical, 66% for extravesical, and 69% for endoscopic approaches. However, notably, endoscopic management of the distal ureter has been reported to lead to a significantly higher intravesical recurrence rate than the transvesical or intravesical approaches (14). Specifically, multiple extravesical recurrences following pluck ureterectomy have been reported (32). These recurrences are typically not easily detectable or salvageable, and most patients will often succumb to disease progression.

COMPLICATIONS

Early complications include hematuria, retroperitoneal hematoma, and retroperitoneal abscess. Ureteral intussusception may be technically unsuccessful in 10% of patients. Prolonged urinary extravasation can in general be managed conservatively with urethral catheter drainage. Although not yet reported clinically, calculi could form on the staple line when the ureteral unroofing technique is used, or urothelial cells could survive in between the staples. Other factors to be considered in the choice of technique include the risk of tumor spillage, the need for visual confirmation of complete resection, the addition of a bladder incision, the need for repositioning, the desired approach to nephrectomy, and surgeon preference. Of these factors, the potential for tumor cell spillage and visual confirmation of complete resection of the distal ureter and bladder cuff are probably the most important regarding outcome. Local recurrence and port site seeding are of concern. Port site seeding has been reported, although the risk of potential seeding does not appear to be higher with laparoscopic techniques than with open surgical techniques (33).

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CHAPTER 24 VESICOVAGINAL FISTULA

HAJAR I. AYOUB AND O. LENAINE WESTNEY

A vesicovaginal fistula (VVF) is an epithelialized or fibrous communication between the bladder and vagina. Physically, psychologically, and socially, it is a source of major distress for the patient contending with urine leakage from the vagina. Documentation of VVFs exists from as early as 1550 BC in the Eber papyrus of ancient Egypt (1). In 1845 James Marion Sims, considered the father of American gynecology, began his exploration into the challenges of treating the condition in Montgomery, Alabama (1). He is credited with developing the foundation of VVF repair and establishing sound surgical principles for repair of fistulas.

The causative factors leading to VVF formation can be broadly categorized into congenital and acquired (Table 24.1). The majority of cases fall into the iatrogenic and obstetrical trauma subcategories. In underdeveloped countries, the leading cause of VVFs is obstetric-related, in which prolonged labor causes ischemic pressure necrosis of the bladder and anterior vaginal wall. In contrast, obstetric trauma accounts for only 5% of VVFs in nations where modern health care is present. The leading cause of VVFs in industrialized countries is iatrogenic surgical trauma, accounting for 82% to 91% of VVFs. Ninety-one percent are due to gynecologic procedures, with 80% due to abdominal hysterectomy (2). The incidence of VVF after transabdominal hysterectomy is 1.0 in 1,000, as opposed to 0.2 in 1,000 after transvaginal hysterectomy. The incidence is highest (2.2 in 1,000) with laparoscopic hysterectomy (3). The most common location for a posthysterectomy VVF is the apex of the vaginal vault or "cuff" corresponding to an intravesical location just superior to the trigone (2). Theoretically, the fistula develops secondary to either unintentional inclusion of full-thickness bladder wall during closure of the vaginal cuff, an unrecognized bladder injury adjacent to the cuff suture line, or cuff abscess.

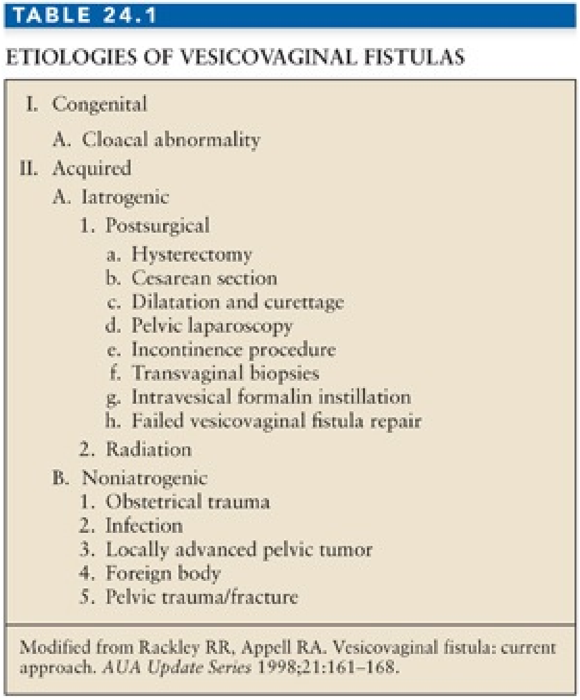

TABLE 24.1

ETIOLOGIES OF VESICOVAGINAL FISTULAS

I. Congenital
    A. Cloacal abnormality
II. Acquired
    A. Iatrogenic
        1. Postsurgical
            a. Hysterectomy
            b. Cesarean section
            c. Dilatation and curettage
            d. Pelvic laparoscopy
            e. Incontinence procedure
            f. Transvaginal biopsies
            g. Intravesical formalin instillation
            h. Failed vesicovaginal fistula repair
        2. Radiation
    B. Noniatrogenic
        1. Obstetrical trauma
        2. Infection
        3. Locally advanced pelvic tumor
        4. Foreign body
        5. Pelvic trauma/fracture

Modified from Rackley RR, Appell RA. Vesicovaginal fistula: current approach. *AUA Update Series* 1998;21:161–168.

DIAGNOSIS

Classically, the postoperative VVF presents with "continuous" urine leakage from the vagina. The time of presentation peaks at 7 to 10 days after surgery but may be variable, with some patients presenting immediately after catheter removal, ranging up to 4 to 6 weeks after surgery (3). In the early postoperative period, there may also be associated ileus and abdominal pain due to intraperitoneal urine extravasation. VVFs due to pelvic irradiation usually have a delayed presentation, developing many months or years posttreatment due to progressive obliterative endarteritis causing tissue ischemia and necrosis.

The key to diagnosis of a VVF is a high index of suspicion. Often, a complete history and physical examination expose the pathology. In the case of less obvious fistula, a dye test is utilized to more clearly visualize the passage of fluid through the fistula. In its simplest form, a saline and dye (indigo carmine or methylene blue) mixture is instilled into the bladder via a Foley catheter while inspecting the vagina for leakage or staining of a previously placed tampon. The failure to identify any discoloration of the tampon may indicate a small fistula or ureterovaginal fistula. The second level of testing requires reinsertion of a vaginal gauze or tampon followed by administration of 5 mg indigo carmine intravenously to determine whether the source is ureteral. Dye from an ureterovaginal fistula may be present on the first gauze inspection prior to intravenous (IV) indigo carmine if there is vesicoureteral reflux, which can be determined with a voiding cystourethrogram (VCUG). An alternative to IV dye injection is oral phenazopyridine hydrochloride, but it requires several hours of lead time before examination. The combination of oral phenazopyridine with intravesical methylene blue furnishes a complete diagnostic picture (4). Identification of orange discoloration on the tampon indicates a ureterovaginal fistula, whereas blue staining in the mid or lower portion of the tampon is suggestive of VVF or proximal urethrovaginal fistula.

All patients should have cystography or VCUG as an initial imaging modality. An IV pyelogram (IVP) or retrograde ureterograms is essential for upper tract evaluation. However, CT urography and/or magnetic resonance imaging have been proven to be helpful in cases where conventional imaging modalities fail (4). Abnormalities to look for include extravasation into the vagina or peritoneal cavity or a displaced or partially obstructed ureter. In patients with VVF, up to 25% will have hydroureteronephrosis, with 10% having a concomitant ureterovaginal fistula (5). In patients with ureteral pathology, a retrograde pyelogram is warranted to evaluate for ureterovaginal fistula if the IVP is not definitive.

Cystoscopy is performed to localize and evaluate the VVF, which often has surrounding edematous mucosa. The size and number of VVFs, their location in relation to the ureteral orifices, any lesions such as foreign bodies (i.e., sutures), tumors, and tissue quality must be noted. If there is a history of malignancy, biopsy of the VVF is indicated to rule out recurrent tumor. Vaginoscopy is performed simultaneous with cystoscopy to assess the vaginal aspect of the fistula. If IVP and retrograde pyelograms are inconclusive, then a fistulogram may be performed transvaginally.

A urodynamic study is recommended to look for other factors that may contribute to the urinary incontinence and may require surgical correction (augmentation cystoplasty, incontinence surgery) with the VVF repair simultaneously. Bladder compliance, capacity, and leak point pressure should be assessed if possible. In cases of a large fistula, a Foley catheter may be used to intubate and occlude the fistulous tract to allow for filling of the bladder.

INDICATIONS FOR SURGERY

The issue of how long to wait before attempting surgical repair of a VVF has long been debated. By tradition, VVF repair is delayed 3 to 6 months to allow inflammation to resolve. In cases where a VVF is due to a complicated operation or after obstetric trauma, this rationale holds true. Moreover, reported success rates in obstetric-induced fistula are less than those posthysterectomy as one would expect based on the mechanism—ischemia. These success rates have ranged widely from 53.6% (6) to 97.5% (7,8), with an average closure rate of 86%. Bukar et al. (9) compared a total of 80 women with obstetric-related VVF with an average size of 5 cm, of which 51% presented early for VVF repair (<12 weeks) and 49% presented late (>12 weeks). Irrespective of early or late repair, no difference was reported regarding closure success rate; however, in the early closure group, the psychological, social, and financial burdens were significantly reduced (9). Furthermore, independent studies by Blaivas et al. (10) and Blandy et al. (11) demonstrated comparable results with early (6 to 12 weeks) repair in cases related to an uncomplicated hysterectomy.

Once surgical repair is planned, the approach needs to be selected—transvaginal, transvesical, or transabdominal. Often, the preference correlates significantly with the experience of the surgeon. Advantages of the transvaginal approach are less blood loss, shorter hospital stay, avoidance of a laparotomy, and thus decreased morbidity. Many reserve the transabdominal approach for those patients requiring concomitant intra-abdominal surgery (ureteral reimplantation, augmentation cystoplasty) or those patients with a narrow and deep vagina causing poor exposure to the VVF. However, Dupont and Raz (12) reported that nearly all VVFs can be accessed and repaired transvaginally.

NONSURGICAL THERAPY—CONSERVATIVE AND ENDOSCOPIC

Upon diagnosis, a trial of conservative therapy may be initiated depending on fistula size. Conservative management consists of prolonged bladder drainage with a Foley catheter, anticholinergic agents to prevent bladder spasms, antibiotics, and estrogen if the patient is postmenopausal. Successful closure of a VVF via conservative means can only be reasonably expected for small fistula—3 to 5 mm in diameter or less.

Other adjunctive minimally invasive treatments include attempts to destroy the epithelial lining of the VVF with fulguration (using electrocautery or laser) and use of occlusive substances. Dogra and Saini (13) reported on a group of eight fistula patients (five failed prior conservative therapy and three failed primary repair) in which holmium:YAG laser was successfully used for circumferential welding of the fistula (2 to 4 mm) in seven of eight patients. In the remaining patient, the procedure was abandoned for bleeding; however, the majority was dry at mean follow-up of 47 months (13).

Since the late 1980s, adhesive materials have been used to treat a variety of fistulas. There are two main types of glues used to treat VVF: fibrin, a biologic product, and synthetic cyanoacrylic glue. The experience with fibrin glue has longer reported follow-up.

A few small series have discussed on the use of fibrin glue to treat VVF demonstrating a good success rate (14,15). Schneider et al. (14) reported six cases using endoscopic techniques and found a 66% closure rate using glue compared with 88% success with a traditional repair. Although it may involve more than one injection to treat the fistula, fibrin glue promotes healing, is biodegradable, and has been used successfully in a large variety of urologic fistulas, including those caused by irradiation (14). Ghoreifi et al. (16) recently described a 100% success rate in 12 patients using autologous platelet-rich plasma injection and platelet-rich fibrin glue interposition (16).

Synthetic cyanoacrylic glue is a relatively newer product in occlusion therapy of fistulas. It polymerizes in 90 seconds once injected and can be used without difficulty in a wet environment such as the genitourinary tract; this, together with its antimicrobial properties, makes it an attractive option for the treatment of VVF. The best results are achieved in fistulas characterized by a long tract and diameter <1 cm. Application can be performed from either transvaginal or cystoscopic approaches with Foley catheter removal between 48 hours and 3 weeks depending on the size of the fistula. Generally, follow-up cystography is performed in 1 to 3 months.

The benefits of using occlusion therapy to treat VVFs include the ability to treat the fistula earlier rather than expecting the patient to endure the distressing symptoms of the fistula for up to 3 months while awaiting definitive surgery. Additionally, there is very low morbidity associated with occlusion therapy. There have been no reported complications from occlusion therapy treatment of VVF, other than the occasional necessity of removing excess glue endoscopically. Importantly, it does not preclude other forms of treatment if it is unsuccessful. Although occlusion therapy appears to be safe and efficacious in selected, small VVFs, more longer term and randomized studies are needed to evaluate its durability.

SURGICAL TECHNIQUES

Transvaginal Approach

Transvaginal VVF repair is the least invasive surgical approach because the vagina in its native state serves as a natural orifice facilitating performance on an outpatient (<24 hour admission) basis. The patient is placed in the dorsolithotomy position. If a narrow vagina is present or the VVF site is high lying, a Schuchardt posterolateral relaxing incision at the 4 o'clock position of the vaginal introitus and distal vaginal wall may be performed to improve exposure. A suprapubic catheter is positioned with a Lowsley retractor, and a urethral Foley catheter is placed. The labia minora are sutured to the inner thigh and a weighted vaginal speculum placed. The VVF is dilated to place an 8Fr Foley catheter. Applying gentle traction to the catheter aids in exposure and dissection of the VVF.

After submucosal injection of a vasopressin mixture (10 U per 100 mL normal saline), lidocaine with 1% epinephrine, or saline to elevate the anterior vaginal mucosa, the VVF is circumferentially incised. A posteriorly based inverted U-shaped incision is made with the apex continuous with the VVF incision (Fig. 24.1). If the VVF is situated deep in the vaginal vault, an anteriorly based U-shaped incision is utilized. The vaginal mucosa is dissected away from the perivesical fascia to form vaginal flaps anterior and posterior to the VVF (Fig. 24.2). Unless nonviable, the fistulous tract is not excised as excision enlarges the defect and risks injury to the intramural ureter. Left intact, the fistula tract also provides strength to the VVF closure, helping decrease the risk of VVF repair disruption due to bladder spasms.

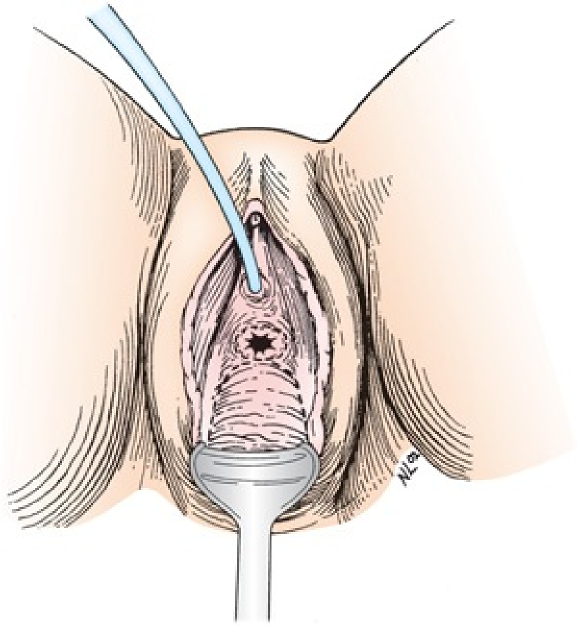

FIGURE 24.1 The apex of the vaginal inverted U incision is continuous with the circumferential fistula incision. (Modified with permission from Raz S, Bregg KJ, Nitti VW, et al. Transvaginal repair of vesicovaginal fistula using a peritoneal flap. *J Urol* 1993;150:56–59. Copyright © 1993 American Urological Association, Inc. Published by Elsevier Inc. All rights reserved.)

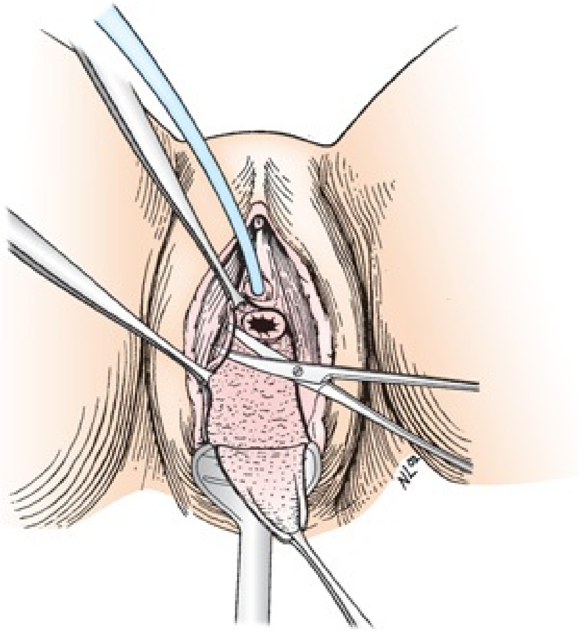

FIGURE 24.2 The vaginal mucosa is dissected away from the perivesical fascia. (Modified from Raz S, Bregg KJ, Nitti VW, et al. Transvaginal repair of vesicovaginal fistula using a peritoneal flap. *J Urol* 1993;150:56–59. Copyright © 1993 American Urological Association, Inc. Published by Elsevier Inc. All rights reserved.)

The fistula is closed in two nonoverlapping, perpendicular layers to prevent fistula recurrence. The first layer closes the fistula with interrupted 4-0 polyglycolic acid sutures, incorporating the vaginal wall overlying the VVF, the fistula tract, and the partial thickness of the bladder wall (Fig. 24.3). The second layer, using 2-0 polyglycolic acid sutures, imbricates the perivesical fascia and the deeper musculature of the bladder over the first layer in a tension-free fashion. The repair is checked for leaks by instilling indigo carmine into the bladder. The vaginal wall is advanced over the VVF repair and closed with an interlocking, running 2-0 polyglycolic acid suture. A Betadine-soaked vaginal pack is placed.

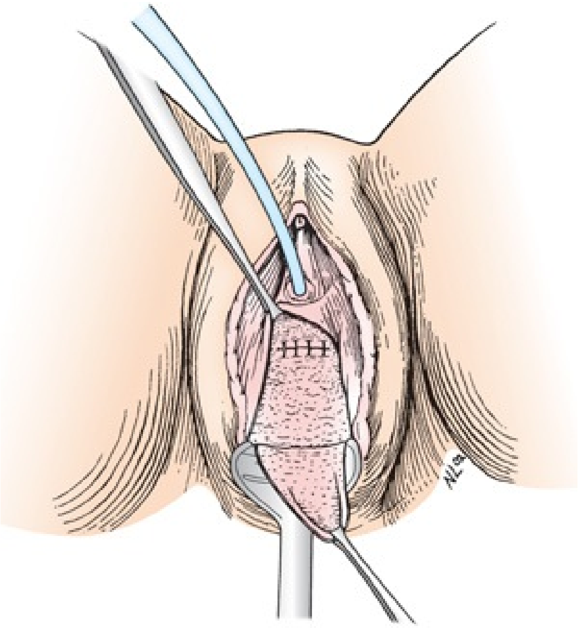

FIGURE 24.3 Closure of the first layer, including the fistulous tract and partial-thickness bladder wall. (Modified with permission from Raz S, Bregg KJ, Nitti VW, et al. Transvaginal repair of vesicovaginal fistula using a peritoneal flap. *J Urol* 1993;150:56–59. Copyright © 1993 American Urological Association, Inc. Published by Elsevier Inc. All rights reserved.)

If there is any concern about the repair, an interposing layer may be placed between the vaginal wall and bladder. The most common options are the Martius labial fat pad and the peritoneal flap.

Alternative tissues include labial, vaginal wall, gluteal, and gracilis muscle flaps. The Martius labial fat pad provides neovascularity and lymphatic drainage, fills dead space, and enhances granulation tissue formation. The flap is harvested by making a vertical incision on the labium majus; the underlying fibrofatty tissue is mobilized. The anterior portion of the graft is tied off (sacrificing the blood supply from the external pudendal artery), leaving the fibrofatty pad supplied by its posterior blood source: the posterior labial artery from the internal pudendal artery. A tunnel is developed from the vaginal incision to the labium majus; the labial fat pad is transferred through the tunnel to cover the VVF repair and secured in place with interrupted 3-0 polyglycolic acid sutures (Fig. 24.4). The tunnel must be sufficiently sized to prevent constriction of the fat pad's blood supply. The labial incision is closed with a 1/4-inch Penrose drain in place unless the graft bed is dry (Fig. 24.5).

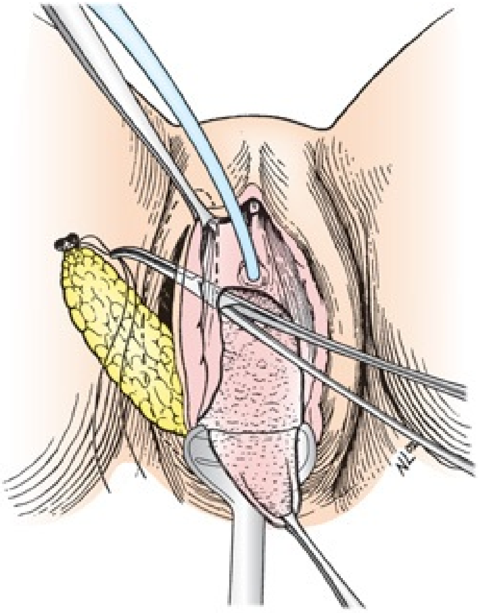

FIGURE 24.4 Using a right-angle clamp, the Martius flap is passed from the labial incision to the vaginal incision.

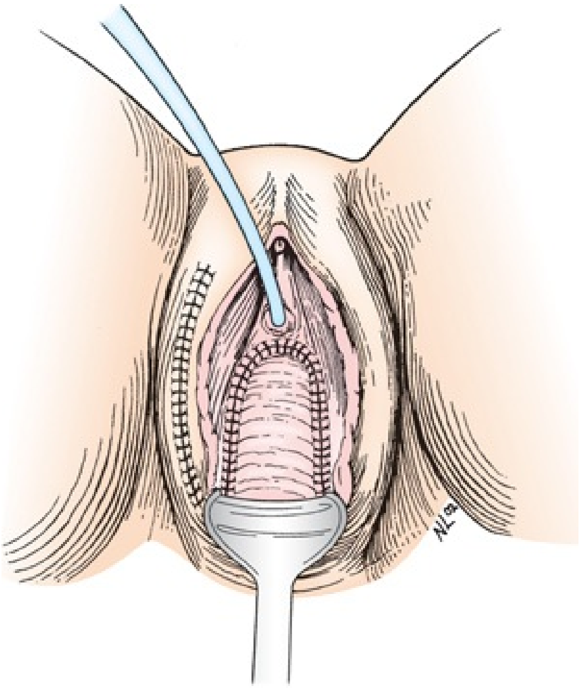

FIGURE 24.5 Closure of the labial and vaginal wall incisions.

Another effective method is peritoneal interposition as described by Dupont and Raz (12) for routine use in fistula repair. With further posterior dissection of the anterior vaginal wall from the bladder, the glistening surface of the peritoneum in the anterior cul-de-sac is exposed. Without entering the intraperitoneal space, the peritoneum is mobilized from the posterior bladder wall to bring it down into the vagina and suture it over the VVF repair site (Fig. 24.6). The peritoneal flap has a 96% success rate when used in transvaginal VVF repair (17).

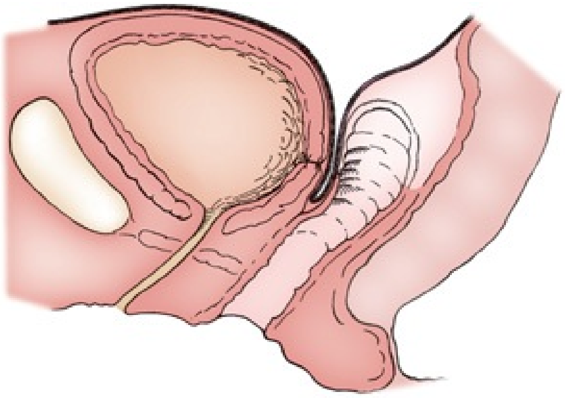

FIGURE 24.6 Interposition of the peritoneum between the bladder and vagina. (Modified with permission from Raz S, Bregg KJ, Nitti VW, et al. Transvaginal repair of vesicovaginal fistula using a peritoneal flap. *J Urol* 1993;150:56–59. Copyright © 1993 American Urological Association, Inc. Published by Elsevier Inc. All rights reserved.)

The vaginal pack is removed on postoperative day 1. The patient is given perioperative antibiotics and anticholinergics to prevent bladder spasms. Two weeks postoperatively, the urethral catheter and suprapubic tube are removed if the cystogram reveals no persistent fistula or extravasation. If a fistula is still present, bladder drainage continues for another 2 to 3 weeks and the cystogram repeated at that time.

Recently, a novel approach to transvaginal surgery has been described by Aybek (18) using a 30-degree optic lens and open surgery instruments transvaginally mimicking laparoscopy through a natural orifice. The authors reported success in all three women for which this technique was used with minimal blood loss and an overnight hospital stay (18).

Transabdominal (Intraperitoneal) Approach

The patient is placed in a low lithotomy position. Cystoscopy is performed to visualize and cannulate the VVF with a 5Fr to 6Fr ureteral catheter or guide wire. If unable to pass the guide wire through the VVF transvesically, it is passed from the vaginal side into the bladder, grasped cystoscopically, and brought out through the urethra.

A midline infraumbilical incision is made; the rectus muscle is split midline to enter the pelvis. The bladder is opened with a midline vertical cystotomy between two stay sutures (Fig. 24.7). The VVF is identified with the guide wire exiting its opening into the bladder. The urethral end of the guide wire is pulled into the cystotomy incision. The VVF’s position in relation to the ureteral orifices is noted and the ureters are cannulated with stents, if necessary. If there is any difficulty identifying the orifices due to local inflammation, IV indigo carmine may be administered.

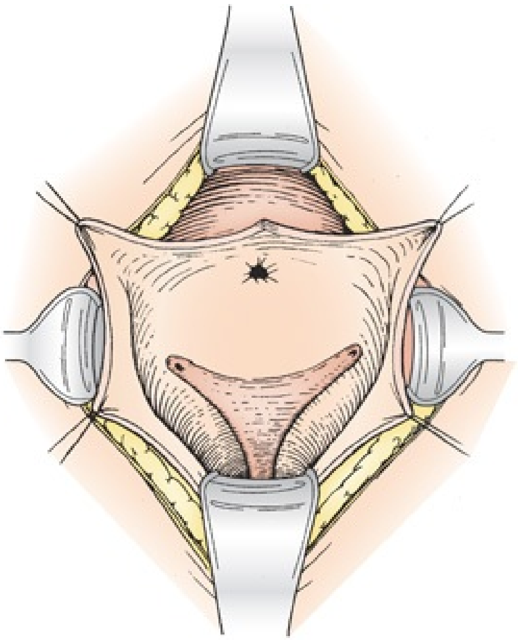

FIGURE 24.7 The bladder is opened in the midline without extending the cystotomy to the fistula.

Entering the peritoneal cavity, the dissection along the posterior bladder wall is carried out until the guide wire traversing the VVF is palpated, indicating the junction between the vagina and bladder. With a sponge stick or endoanal sizer in the vagina to help delineate the vagina, the bladder is carefully dissected away from the vagina. Wide mobilization of the bladder and vagina to allow tension-free closure of each side of the VVF is critical. The dissection bisects the fistula tract without excising the tract extending 1.5 to 2.0 cm beyond the VVF, allowing for tension-free closure (Fig. 24.8). Using interrupted 3-0 polyglycolic acid sutures, the vaginal defect is closed in two nonoverlapping layers. The bladder defect is also closed in two nonoverlapping layers, with running 4-0 polyglycolic acid and 3-0 interrupted sutures.

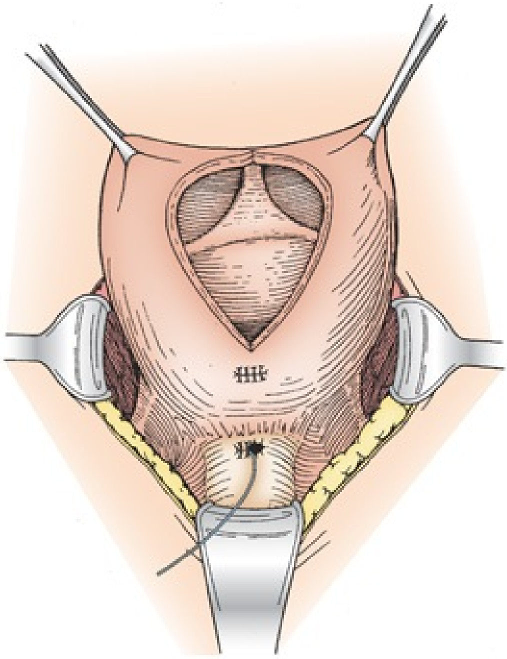

FIGURE 24.8 After dissecting between the bladder and vagina, both defects are closed in two layers.

After the bladder and vaginal fistulous defects are closed, attention is turned to developing an omental pedicle flap to interpose between the bladder and vagina. Evans et al. (19) recommended routine use of an interposition flap during intra-abdominal VVF repair, noting a success rates of

100% and 63% to 67% with and without a flap, respectively. Not only does the interposition flap add an extra layer to the VVF repair to prevent recurrence, but it also increases lymphatic drainage and decreases the risk of infected fluid collection. However, there have been several recent case reports where success of VVF was achieved without using a flap in patients with VVF recurrence after undergoing repair with tissue interposition (20).

The greater omentum is identified, and an omental flap based on the more reliable right gastroepiploic artery is developed (Fig. 24.9). The flap is brought down to the pelvis and placed between the bladder and vagina, covering the fistula repair (Fig. 24.10). The graft is secured in place with interrupted 3-0 polyglycolic acid sutures. Alternatives to omentum include lateral pelvic peritoneum, pericolic or mesenteric fat, and free bladder mucosal graft. The urachal flap, a newly reported alternative, was recently described by McCammon (21) associated with successful repair of 12 out of 13 patients with VVF (21). Of the 13 patients, none had previous pelvic irradiation and 5 had failed prior repair. The fistula size ranged from pinpoint to 1.5 cm, and most were located proximal to the trigone on the posterior wall. In the one failure who also suffered from a wound evisceration, she subsequently underwent successful repair using a Martius flap.

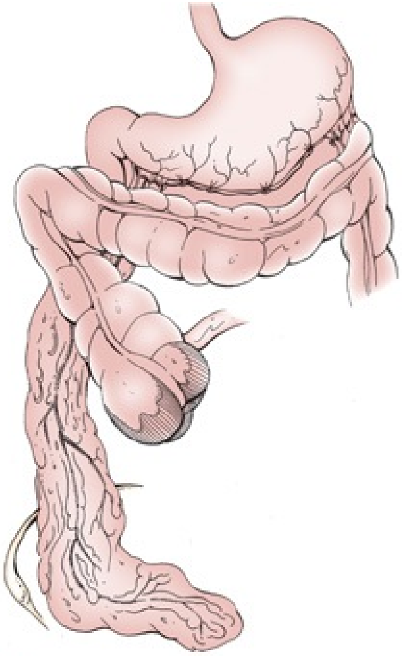

FIGURE 24.9 Development of an omental pedicle flap based on the right gastroepiploic artery.

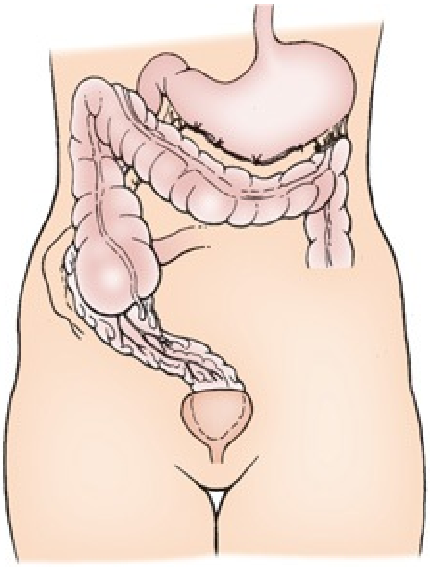

FIGURE 24.10 Placement of the distal end of the omental graft posterior to the detrusor covering the repairs.

With the VVF repair completed, a suprapubic catheter and urethral Foley catheter are placed with 5-mL balloon inflation each. In patients with long-term, large fistula, the bladder capacity is reduced due to the constant drainage. Therefore, the placement of two fully inflated balloons in combination with irritation from the incisions may lead to intensification of bladder spasms. Therefore, a Malecot-type catheter without a balloon is another option to reduce irritative symptoms. The vertical bladder incision is closed in two layers with 2-0 polyglycolic acid sutures. A closed pelvic drain is also placed. Postoperative care is similar to that after transvaginal VVF repair.

An alternative to the previously described intra-abdominal technique is the standard O'Conor technique. The bladder is bivalved posteriorly from the dome to the level of the VVF. Then, the VVF is excised entirely (Figs. 24.11 through 24.13). After further dissection of the bladder from the vagina, the vaginal defect is closed in two nonopposing layers with interrupted absorbable sutures (Fig. 24.14). An interposition flap is tacked over the vaginal closure and the bladder is closed. The first technique is slightly more difficult in that the fistula is approached posteriorly and transected between the bladder and vagina. However, the advantages are that the smaller cystotomy is separated from the repair.

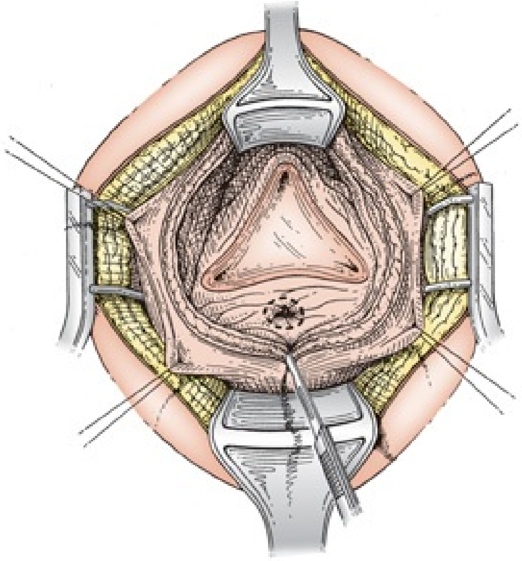

FIGURE 24.11 Cystotomy extended down to the fistula site.

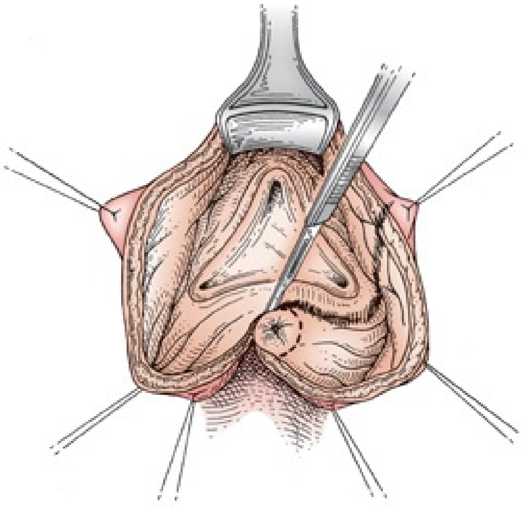

FIGURE 24.12 Circumscribing incision around the fistula.

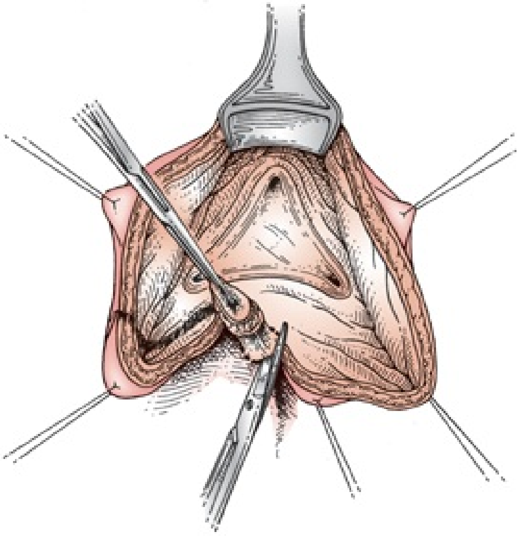

FIGURE 24.13 Sharp excision of the fistula tract.

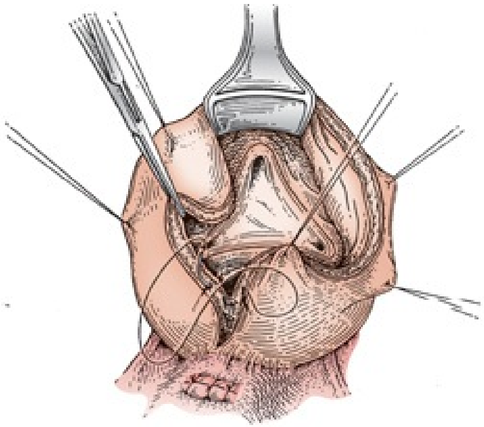

FIGURE 24.14 Relation of the cystotomy to the vaginal closure.

Transvesical (Extraperitoneal) Approach

The advantage of this approach is that one can avoid entering the peritoneal cavity. Through a midline infraumbilical incision, the bladder is identified and opened with a midline vertical incision. The VVF is located and the ureteral orifices are cannulated with stents. The fistulous opening is circumscribed carefully with a scalpel, incising only the thickness of the bladder mucosa and staying out of the vagina. This is performed to leave the fistula tract intact, along with a 2- to 3-mm ring of bladder mucosa. With sharp dissection directed radially away from the VVF for 1 to 2 cm, the bladder is mobilized away from the vagina (Fig. 24.15). To help with exposure, a Foley catheter may be placed transvesically in the VVF for upward traction.

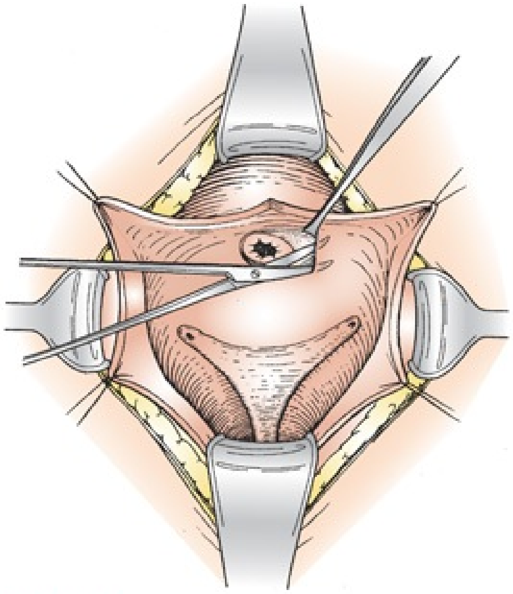

FIGURE 24.15 Transvesical development of the plane between the bladder and vaginal walls.

With interrupted 3-0 polyglycolic acid sutures, the fistula and vagina are closed together. Next, the bladder muscle is closed perpendicular to the fistula and vaginal closure, also with 3-0 polyglycolic acid sutures. Finally, the bladder mucosa is closed with running 4-0 polyglycolic acid sutures. A suprapubic cystotomy catheter and a urethral Foley catheter are placed followed by closure of the bladder in two layers with 2-0 polyglycolic acid sutures. Postoperative care is similar to that previously described.

Laparoscopic and Robot-Assisted Repair of Vesicovaginal Fistulas

With the high success of the transvaginal approach, the decision to repair a VVF using a transabdominal approach requires some justification based on the characteristics of the fistula, inciting etiologic factors and history of prior repair. High VVFs, fistulas situated close to the ureteric orifices, or those with failed vaginal repair, may be better served by using a transabdominal approach because of its higher success rate. An abdominal incision, however, is associated with a higher morbidity risk and longer recovery time for the patient. The development of minimally invasive surgical techniques led to the application of laparoscopic techniques for the repair of VVF. Nezhat et al. (22) was the first to report correction of a VVF using a laparoscopic approach in 1994. Its limitations have centered on dissection of adhesions and fibrosis around the fistula and application of sutures in a tension-free manner. Recent studies show a 100% success rate by several authors, but this remains in a small number of patients with primary fistulas. Table 24.2 summarizes the most recent studies comparing laparoscopic, robot-assisted, transvaginal, and open abdominal approaches in VVF repair. The development of the robot-assisted laparoscopic approach has reduced many of the challenges faced in the surgical repair of the VVF.

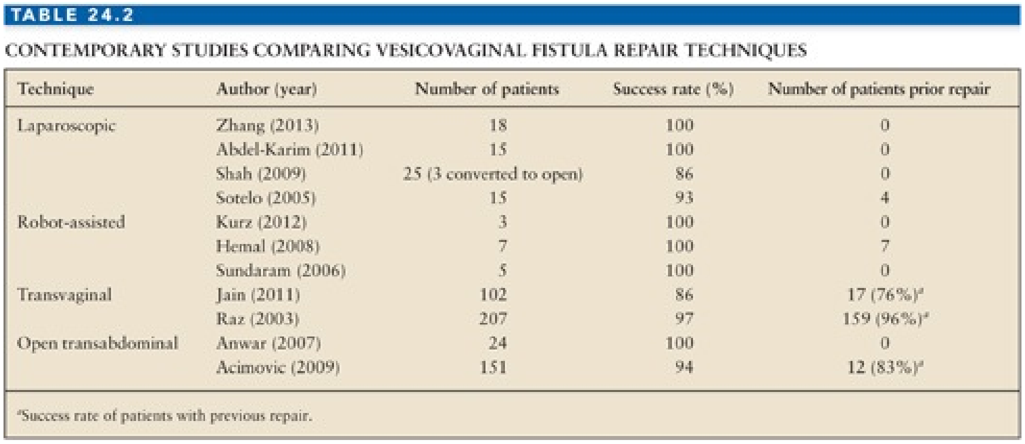

TABLE 24.2

CONTEMPORARY STUDIES COMPARING VESICOVAGINAL FISTULA REPAIR TECHNIQUES

Technique	Author (year)	Number of patients	Success rate (%)	Number of patients prior repair
Laparoscopic	Zhang (2013)	18	100	0
	Abdel-Karim (2011)	15	100	0
	Shah (2009)	25 (3 converted to open)	86	0
	Sotelo (2005)	15	93	4
Robot-assisted	Kurz (2012)	3	100	0
	Hemal (2008)	7	100	7
	Sundaram (2006)	5	100	0
Transvaginal	Jain (2011)	102	86	17 (76%)[a]
	Raz (2003)	207	97	159 (96%)[a]
Open transabdominal	Anwar (2007)	24	100	0
	Acimovic (2009)	151	94	12 (83%)[a]

[a] Success rate of patients with previous repair.

The potential benefits offered by laparoscopic and robotic repair of VVFs include shorter recovery time, reduced morbidity, less blood loss, better cosmesis, and improved visualization of the fistula and adjacent tissues, facilitating more precise extensive dissection around the fistula. The surgeon is also able to perform other concomitant procedures such as ureteral reimplantation or augmentation cystoplasty, if necessary. As the operation is traditionally performed using a transperitoneal approach, it is easily amenable to laparoscopic techniques. The first complete transabdominal laparoscopic and robotic repairs of a VVF were performed in 1994 and 2005, respectively. Evidence for the efficacy and safety of this approach is based on few small series of nonrandomized reports and case reports. In Sotelo's series, 14 out of 15 patients were cured using the laparoscopic approach at a mean follow-up of 26 months (23).

Gupta et al. (24) in 2010 compared the outcomes between recurrent VVF repaired in either open or robotic fashion. Twelve patients in the robotic arm were matched based on patient demographics, fistula etiology, prior repairs, and fistula size to 20 patients in the open arm. The resultant success rates were 100% in the robotically managed group versus 90% in the open group; however, it was not statistically significant due to sample size. Nonetheless, mean blood loss (88 versus 170 mL) and hospital stay (3.1 versus 5.6 days) were significantly less with a *P* value <.05 when comparing between robotic and open groups, respectively (24).

The technical advances afforded by the laparoscopic technique include the need for a minimal cystotomy, often in a reverse tennis racquet fashion with minimal bladder mobilization and magnified anatomy enhancing visualization of the fistula margins. Robotic assistance has decreased the fatigue factor of the surgeon, minimized the technical difficulty associated with placement of tension-free sutures to the bladder and vagina, and improves the surgeon's depth perception.

Either a four- or five-port system is used for laparoscopic or robotic approach, respectively. The fistula may be catheterized to reduce loss of pneumoperitoneum, and the bladder is catheterized with a Foley catheter after careful localization of the fistula using vaginoscopy and cystoscopy. If the fistula is close to the ureteric orifices, the ureters are cannulated to allow easier localization. Minimal cystotomy is performed around the fistula, and the fistula is repaired in the usual fashion via the mini-O'Conor approach (25). Tissue interpositioning can also be applied, usually using omentum. Average operation times run around 140 to 233 minutes, with an average length of stay of approximately 4 days. The Foley catheter is removed on days 10 to 14, preceded by cystography.

Laparoscopic and robotic techniques can be applied safely and effectively in the treatment of supratrigonal and large VVFs. This technique offers many potential benefits to the patient; however, there remains a paucity of randomized studies to quantitate its true effectiveness. It is also an evolving area, with the potential for further advances in surgical technique.

Technique Controversies

Tissue Interposition

Tissue interposition has been advocated historically, especially in recurrent VVF. However, recent evidence by Flynn et al. (26) suggests that there is no added benefit in the success rate of benign VVFs. The patients were in two groups: 25 patients with primary VVF and 24 patients with recurrent VVF. Hysterectomy was the etiology of the fistula in most patients being 88% in group 1 and 95% in group 2. The mean fistula size was 7.1 ± 4.8 mm in group 1 and 6.7 ± 8.6 mm in group 2. All repairs were done transvaginally and patients were discharged with only a suprapubic catheter for drainage that was typically left for 3 weeks. The authors, however, state that tissue interposition should be used in the face of lack of local tissue after fistula excision and/or poor tissue quality resulting from chronic infection or steroids. As such, the decision for tissue interposition should not be based on recurrence but rather individualized based on fistula etiology and integrity of local tissue (26).

Excision of Fistula Edges

Another technical point that has been questioned is the classical teaching of trimming the edges of the fistula to obtain bleeding, well-vascularized tissue. Mourad (27) studied 64 women randomized into two groups with no difference in fistulae characteristics. The cure rates were not statistically different based on trimming of the fistulous tract edges versus inclusion of the original fistulous edges. Anecdotally, however, the authors did note in the event of recurrence, the fistulous tract was larger when the edges were trimmed. This led to the conclusion that there is no added benefit to trimming the edges with a potential negative effect in patients with subsequent recurrence (27).

OUTCOMES

Complications

Clearly, the most problematic complication is recurrent or persistent fistula. The catheter is replaced for several weeks and the cystogram repeated. If the fistula fails to resolve or improve, then endoscopic evaluation—vesical and vaginal—is performed in preparation for a second procedure. For recurrent fistulas complicated by prior pelvic irradiation, a conservative approach is wise, waiting 6 to 12 months before attempting repair. Frequency, urgency, and urge incontinence in the early preoperative period are treated symptomatically with anticholinergic therapy. These, however, are expected due to bladder decompensation and trigonal/suture line irritation. Residual incontinence must be evaluated with physical examination and fluoroscopic urodynamics. Occult or de novo stress urinary incontinence occurring in 10% to 12% of patients requires separate treatment after recovery from the VVF repair. Ureteral obstruction, prolonged ileus, and bowel obstruction are uncommon.

Results

A review of the VVF series from the last two decades demonstrates the success rate of transvaginal and transabdominal repairs to be 92.5% to 96% and 85% to 100%, respectively (10,11,17,28). Laparoscopic and robot-assisted VVF is still growing with very small series reporting results comparable to conventional techniques. Therefore, when the appropriate approach is selected based on the etiology, location, concomitant pathologies, and surgeon experience, excellent results can be expected in the great majority of patients. However, in those who have failed multiple repairs due to severe tissue compromise secondary to radiation or who have developed the end-stage detrusor, diversion may be the only alternative.

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CHAPTER 25 INTESTINOURINARY FISTULAS

RYAN L. MORI, ERIC A. KLEIN, AND KENNETH W. ANGERMEIER

An intestinourinary fistula is a pathologic extra-anatomic epithelialized connection that can be described based on the respective intestinal and urologic segments involved (i.e., enterovesical, colovesical, rectovesical, rectourethral). This chapter will describe the etiology, evaluation, and management of intestinourinary fistulas with special emphasis on intestinovesical and rectourethral fistulas.

INTESTINOVESICAL FISTULAS

Etiology

The etiology of enterovesical and colovesical fistulas can be divided into three broad categories: inflammatory, neoplastic, and traumatic (Table 25.1). In modern series, diverticular disease is the most common etiology representing 67% of cases, followed by malignancy in 15% and Crohn disease in 9% (1,2). A history of pelvic irradiation increases susceptibility and complexity. Men are affected twice as commonly as women due to the presence of the uterus and broad ligament as a protective barrier. Up to 50% of women with colovesical fistulas have undergone previous hysterectomy (3).

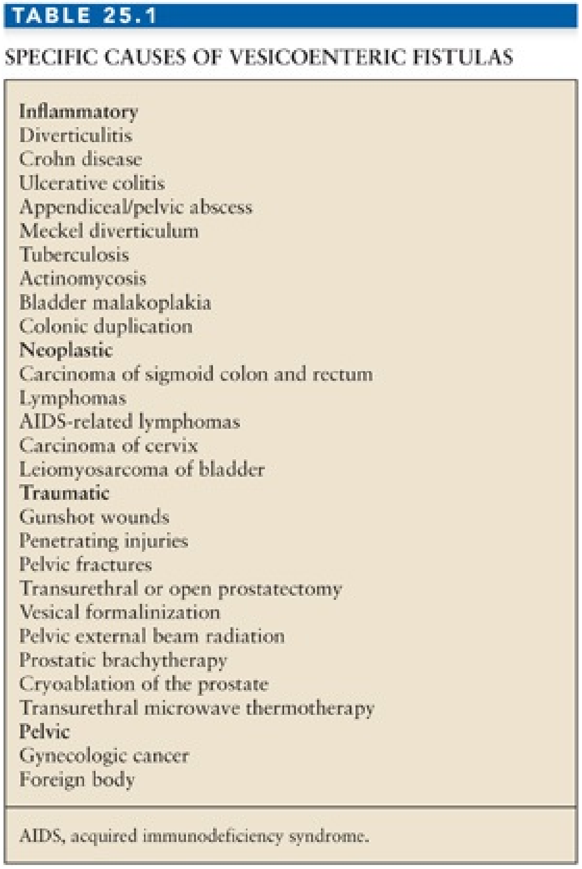

TABLE 25.1

SPECIFIC CAUSES OF VESICOENTERIC FISTULAS

Inflammatory
Diverticulitis
Crohn disease
Ulcerative colitis
Appendiceal/pelvic abscess
Meckel diverticulum
Tuberculosis
Actinomycosis
Bladder malakoplakia
Colonic duplication
Neoplastic
Carcinoma of sigmoid colon and rectum
Lymphomas
AIDS-related lymphomas
Carcinoma of cervix
Leiomyosarcoma of bladder
Traumatic
Gunshot wounds
Penetrating injuries
Pelvic fractures
Transurethral or open prostatectomy
Vesical formalinization
Pelvic external beam radiation
Prostatic brachytherapy
Cryoablation of the prostate
Transurethral microwave thermotherapy
Pelvic
Gynecologic cancer
Foreign body

AIDS, acquired immunodeficiency syndrome.

Diagnosis

Although the inciting pathology is usually intestinal, the presenting symptoms are often urinary in nature. The most common presenting complaints are pneumaturia reported in 57% to 91% and fecaluria in 42% to 76%. Recurrent urinary tract infections, irritative voiding symptoms, and abdominal pain are also common, whereas passage of urine per rectum is not typical (1–4). Physical signs suggestive of enterovesical fistulas are often subtle or absent but may include a palpable mass or abdominal tenderness with or without local peritonitis. Associated physical findings are more commonly associated with fistulas secondary to inflammatory bowel disease (5). In patients with rectal disease, a rectal abnormality or tenderness may be present. Urinalysis usually reveals pyuria with or without hematuria, and urine cultures are positive in the majority of patients with the most common growth patterns being multiple organisms or isolated *Escherichia coli* (2).

Given the symptomatic nature of enterovesical and colovesical fistulas, the diagnosis is typically a clinical one. The goal of assessment is not only to diagnose and localize the fistula but also to identify and develop a treatment strategy for the underlying intestinal or urinary pathology. Radiographic assessment is used as an adjunct and may assist with anatomic localization and surgical planning. Traditionally, barium enema has been used as a first study, but more recent series have demonstrated fistula identification rates of only 20% to 42% (1–4). Other imaging modalities including computerized tomography (CT) and magnetic resonance imaging (MRI) have mixed results in the literature in terms of diagnosis. However, although axial imaging may fail to demonstrate the fistula, it may aid in surgical planning and identification of etiology and may be diagnostic based on the associated indirect findings of the fistula including air in the bladder or focal bladder or bowel wall thickening. In our institution, the use of CT cystography has replaced other anatomic and functional studies including standard cystography, CT urogram, and MRI.

Functional studies have been described for the diagnosis of enterovesical fistula and include the charcoal test, urinary or rectal visualization of administered dyes, the poppy seed test in which the urine is evaluated for orally consumed poppy seeds, or the Bourne test where urine is examined for barium following a nondiagnostic barium enema. Although the sensitivities of these tests may approach 100% in the literature (4), they are seldom performed because they often fail to provide anatomic detail and the diagnosis of fistula is usually self-evident based on the clinical picture.

Direct visualization with colonoscopy and cystoscopy is a key component of the analysis. Colonoscopy rarely identifies a fistula tract but is recommended for its importance in evaluating the etiology and extent of the intestinal disease (1–4). Cystoscopy is the most common abnormal investigation. Although fistula identification rates are reported to be from 10% to 60% (1,3), up to 90% of cystoscopies may show indirect evidence of the fistula including bullous edema or inflammatory bladder wall abnormalities (2).

Management

Given the symptomatic nature, the potential for morbidity, and the associated underlying bowel pathology, most intestinovesical fistulas should be addressed surgically. The principles of surgical management include removal of the diseased segment of intestine as well as the fistula tract with or without defunctionalization of the affected bowel segment with a proximal diversion. Typically, the bladder can be managed with 7 to 10 days of catheter drainage with minimal need for resection or repair especially in the setting of benign bowel disease (6). Larger bladder injuries are typically managed with two-layered closures. For this reason, surgery is often directed by the colorectal surgeon with assistance from the urologist when necessary.

A one-stage approach with bowel resection and reanastomosis has become the standard because it is associated with fewer complications and lower mortality, but management must be based on the underlying pathology on a case-by-case basis. Even in the setting of abscess or purulent peritonitis, a one-stage approach can still be safely performed given that the inflammatory focus is resectable and the bowel anastomosis can be “quarantined from any inflammatory nest” (3). A two-stage approach should be considered in patients with bowel obstruction or when there is concern for a healthy anastomosis such as in the setting of extensive locoregional abdominal sepsis, significant inflammation, or in the setting of prior radiation. The two stages may consist of bowel resection with a Hartmann procedure followed by reanastomosis, or resection with anastomosis and proximal diversion followed by delayed restoration of bowel continuity. Some patients, especially those with a history of radiation, may require permanent bowel and/or bladder diversion.

Nonoperative or minimally invasive management may be considered in patients who are deemed unfit for surgery. Spontaneous closure is rare but may occur especially in the setting of traumatic rather than inflammatory fistulas. Evaluation of several series of patients with intestinovesical fistula provides some information on patients who refuse or are unfit for surgery. Although Amin et al. (7) demonstrate that patients with diverticular colovesical fistulas may get by without significant complications in some circumstances, Thomas et al. (1) demonstrate a high rate of mortality without intervention.

Surgical Technique

One-Stage Surgery

On the day prior to surgery, a mechanical bowel preparation is administered and the patient is maintained on a clear liquid diet. Gram-negative and anaerobic coverage is provided by administering a third-generation cephalosporin and metronidazole within 1 hour of surgical incision.

The majority of fistulas can be best approached by a midline laparotomy incision extending from the pubic ramus to the umbilicus (Fig. 25.1), with cranial extension as needed. The peritoneum is entered, adhesiolysis is performed as needed, and the site of the fistula is identified. The remainder of the procedure is determined by the underlying disease causing the fistula and any associated complications. Patients with Crohn disease often have multifocal fistulas not involving the urinary tract and may require multiple resections or strictureplasties. In malignant fistulas, the requisite oncologic procedure is performed with resection of the fistula tract.

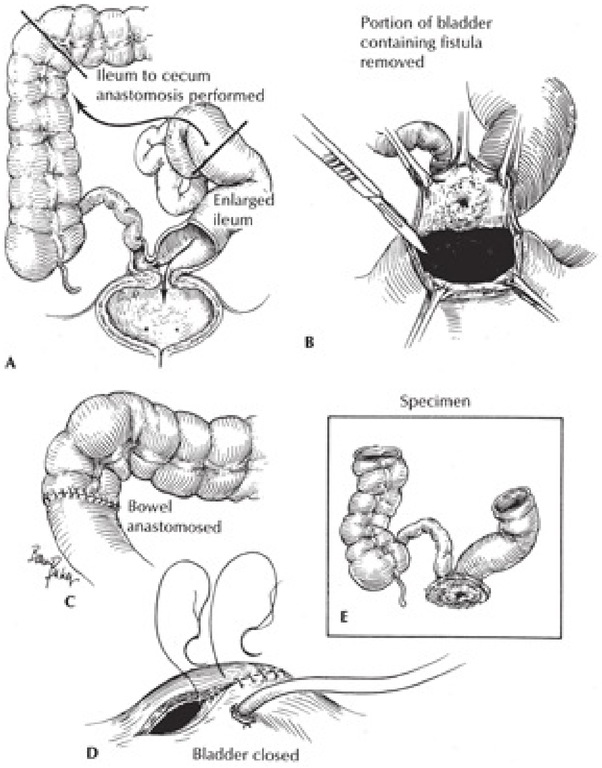

FIGURE 25.1 Management of an enterovesical fistula using bowel resection and restitution with primary bladder closure.

Fistulas associated with malignancy or large cystotomies may require partial cystectomy. Closure of small or unidentified cystotomies is not essential. Larger bladder defects should be closed in two layers with absorbable suture. A large or difficult to access bladder defect may require a midline anterior cystotomy. In the setting of ureteral involvement, ureteroneocystostomy may be required. Whenever possible, healthy tissue such as an omental or peritoneal flap should be interposed between the bowel and the bladder repairs, especially in the setting of radiation or poor tissue quality. Extraperitoneal drainage should be conducted, especially in the setting of a large bladder repair. A urethral catheter should be maintained for at least 7 days postoperatively, and in the setting of a more involved bladder repair, suprapubic catheter drainage may be used as well. A laparoscopic approach has also been described with good success (8).

Outcomes

The overall complication rate from intestinovesical fistula surgery has been reported to range between 6.4% and 49% (1). Major complications of the surgical management of intestinovesical fistula include death (0% to 3.5%), cardiopulmonary event (1.3% to 6.7%), deep venous thrombosis (0% to 1.2%), anastomotic leak (1.1% to 5.3%), prolonged ileus (0% to 4.8%), enterocutaneous fistula (0% to 1.2%), and wound infection (10% to 20%). Fistulas secondary to radiation and malignancy are associated with greater morbidity (9–11).

The results of the one-stage procedure for enterovesical fistula are dependent on the etiology of the fistula. The fistula recurrence rate in the setting of diverticular disease is virtually nonexistent (1,3). However, fistula recurrence in the setting of Crohn’s disease or malignancy can occur in up to 13% and 15% of patients, respectively (9,12). Urinary leak rates are very low but have approached 8% in small series (12) of fistulas in Crohn patients.

RECTOURETHRAL FISTULAS

Background

Over the past decade, there have been some changes in the surgical approach to rectourethral fistulas (RUFs). This has corresponded with a number of new therapies for prostate cancer and the transition of management toward the urologic surgeon. There are several surgical approaches that are acceptable. The management of each case is unique and must consider fistula etiology, complexity, associated urinary or bowel dysfunction, associated urethral or bladder neck stricture, and patient performance status.

The urologic surgeon should be familiar with the transperineal approach because it offers excellent exposure to both the urinary and rectal components of the fistula, allows for multiple potential interposition flaps, and is applicable to the repair of both simple and complex fistulas.

Etiology

RUFs have long been considered a rare clinical entity, but the incidence is increasing in tandem with the increase in treatment for prostate cancer. The etiology of the majority of RUFs is iatrogenic secondary to surgical, ablative, or radiation therapy to the prostate for prostate adenocarcinoma with combination therapy further increasing the risk. The overall risk for surgical RUF during radical prostatectomy may be as high as 0.53% according to one large contemporary series and is threefold higher following perineal prostatectomies (1.04%) compared to retropubic prostatectomies (0.34%) (13). Radiation-induced fistulas accounted for only 3.8% of all reported cases of RUF prior to 1997 (14), but recent series suggest that radiation or ablative energy are involved in up to 64% of rectourethral fistulas (10,15,16) with a steadily increasing incidence over the past decade. Brachytherapy can result in rectourinary fistula in 0.6% to 2.4% (17–19), and in cases of combined brachytherapy and external beam radiotherapy, the incidence is as high as 2.9% (19). Salvage therapies following primary surgery or radiation for prostatic carcinoma can have an even higher incidence of RUF (20,21). Fistulas can occur anytime following radiation ranging from several months to many years (14). Historically, RUF has also occurred in the absence of malignancy in the setting of congenital defects, trauma, pelvic surgery, and inflammatory bowel disease (22) as illustrated in Table 25.1.

Diagnosis

Similar to other intestinourinary fistulas, the diagnosis of RUF is clinical and is suggested by any combination of fecaluria, pneumaturia, or the passage of urine per rectum in a patient with risk factors for RUF. Unlike intestinovesical fistulas, passage of urine per rectum is the most common observance and occurs more frequently than pneumaturia and fecaluria (6). Patients may also present with infectious sequelae including recurrent urinary tract infections or sepsis. Rectal pain may be an early sign before other manifestations occur. In a patient with a history of radiation and an ulcerative anterior rectal lesion, rectal biopsy is cautioned against because there is an increased risk of subsequent fistula formation (23).

Diagnosis of rectourethral fistula is driven by the combination of endoscopy, radiographic imaging, and combined examination under anesthesia by both the colorectal and urologic teams. Digital rectal examination and proctoscopy help to assess the size and the location of the fistula relative to the dentate line as well as the integrity of the rectal mucosa and the anal sphincter. Cystoscopy allows for identification of the likely fistula site as urethral or vesicular as well as assessment of the bladder for capacity, radiation cystitis, and proximity of the fistula tract to the ureteral orifices. Presence of a urethral stricture, typically within the membranous urethra, should also be noted. Radiographic tests of importance include retrograde urethrogram, voiding cystourethrogram, and computerized tomography of the pelvis.

It is imperative during the workup to differentiate between complex and simple rectourethral fistulas. We consider simple fistulas to be small in size and secondary to surgery or trauma in the absence of radiation, ablative energy, or local tissue destruction. Surgical fistulas that are very large, or those that occur in the setting of local tissue damage or radiation effect, are considered to be complex (24,25). This distinction is important because the surgical management and expected outcomes differ for simple fistulas compared to complex ones.

Management

Rectourethral fistula represents a surgical problem in the majority of patients. Spontaneous closure is a rare event, especially in the setting of complex fistulas. However, up to 33% spontaneous closure rate has been described in cases of small surgical fistulas with urinary and fecal diversion alone (13) and has rarely been seen in cases of complex fistulas as well (26). The majority of patients with a complex RUF will require a combination of urinary or bowel diversion, and often both. In the setting of a simple RUF, this may not always be required and is done on a case-by-case basis. Urinary diversion can be achieved with a urethral catheter or a suprapubic catheter. Fecal diversion can be done laparoscopically, and the choice of a temporary versus a permanent diversion is based on the integrity of the anorectal function as well as the size of the fistula and the integrity of the surrounding tissues.

Typically, we perform combined exam under anesthesia, cystoscopy, proctoscopy, and laparoscopic fecal diversion if necessary as the first step in management. Some argue that in the absence of significant infections or sepsis, diversion can be delayed until the time of definitive repair (21). However, in the presence of radiation or ablative energy, or larger fistulas with poor local tissue quality, combination urinary and fecal diversion is recommended. Typically, we allow 3 to 6 months of diversion prior to repair in the case of complex fistulas.

Surgical management of RUF requires an individualized management strategy. Often multiple stages are required and the patient should be counseled appropriately. There are five key factors which must be considered in each case.

1. Sphincteric function
2. Presence of urethral stricture or bladder neck contracture
3. Status of the adjacent tissue
4. Size and location of the fistula
5. Overall condition and life expectancy of the patient

Sphincteric Function

In the setting of presurgical anorectal sphincteric incompetence, permanent fecal diversion should be offered in place of complex anal sphincter-sparing surgery. In the setting of urinary sphincteric deficiency, the patient must be counseled on the options of supravesical diversion or fistula repair followed by delayed implantation of an artificial urinary sphincter.

Presence of Urethral Stricture or Bladder Neck Contracture

Concurrent urethral strictures can occur in up to 11% of nonradiated RUF patients and up to 28% of those with fistulas secondary to radiation/ablation (15). Obstruction distal to the site of fistula repair may compromise an otherwise adequate repair and thus should be corrected prior to or simultaneously with RUF repair.

Status of Adjacent Tissue

Fistulas following pelvic radiation or ablative energy are often large and more complex. Radiation causes damage to endothelial cells, connective tissue, and vasculature, and these ischemic changes may compromise surgical repair. Even with healthy tissue interposition, failure rates in the setting of radiation and ablation are higher (16,19). Further, patients with radiation/ablation are more likely to require permanent fecal or urinary diversion (27).

Size and Location of the Fistula

Small and distal fistulas in the absence of radiation or ablative energy may be repaired through a transanal or transsphincteric approach. Larger fistulas and those associated with tissue damage secondary to radiation often require a transperineal, abdominal, or combined approach. Some patients with very large fistulas or troublesome sepsis or bleeding may require permanent urinary and fecal diversion and pelvic exenteration.

Overall Condition and Life Expectancy of the Patient

Poor surgical candidates may be best managed by a combination of permanent fecal and/or urinary diversion.

The panacea of surgical therapy for rectourethral fistula consists of fistula closure, interposition of healthy well-vascularized tissue, and preservation of orthotopic bowel and bladder function. Even the most complex fistulas (multiple ablative therapies, complicated surgical repair, or prior failed repair) are potentially amenable to repair with preservation of both orthotopic bowel and bladder function (28,29).

Surgical Approaches

Multiple surgical approaches exist for the treatment of RUF. Historically, the transanal and transanosphincteric approaches have dominated the literature. A more recent analysis of the literature shows transperineal repair in 66% of cases followed by transsphincteric (15.7%), transabdominal (12.5%), and transanal (5.9%) (30). Due to the relative rarity of occurrence and the shared surgical obligation of colorectal and urologic surgeons, there is limited data on the best approach for repair. The distinction between simple and complex RUF is of paramount importance because the surgical management and expected outcomes differ. As the burden of care shifts toward urologic surgeons, the transperineal approach has become the favored one in our hands for both simple and complex fistulas because it provides excellent exposure to both the urethral and rectal sides of the fistula and allows for the simultaneous management of urethral stricture and allows options for tissue interposition.

Surgical Approaches for Simple Rectourethral Fistulas

Those fistulas that are small and postsurgical can be approached in several ways depending on their location. Although the transanal and transanosphincteric approaches have been successful historically, we feel that the transperineal approach is well suited for all RUFs. Typically, prior or concomitant fecal diversion is at the discretion of the surgeon, and failure rates are acceptably low when diversion is omitted in selected cases.

Transanal Approach. This approach is well suited for small and distal postsurgical fistulas not associated with prior radiation, ablation, or poor local tissue quality. The patient is placed in a jackknife position. A speculum is inserted transanally to expose the fistula. If appropriate exposure is not possible then another technique should be chosen. If exposure allows, a full-thickness U flap of rectal wall is elevated, mobilized, and advanced over the fistula in a two-layer closure (Fig. 25.2). Alternatively, the fistula tract may be excised circumferentially with the adjacent rectal mucosa and the rectal wall muscle and mucosa closed separately. The use of this approach is decreasing as the incidence of radiation induced fistulas rises, but it is well tolerated and has success rates ranging upward of 70% to 100% (31–33). Typically, a urinary catheter is left indwelling for 2 to 3 weeks postoperatively.

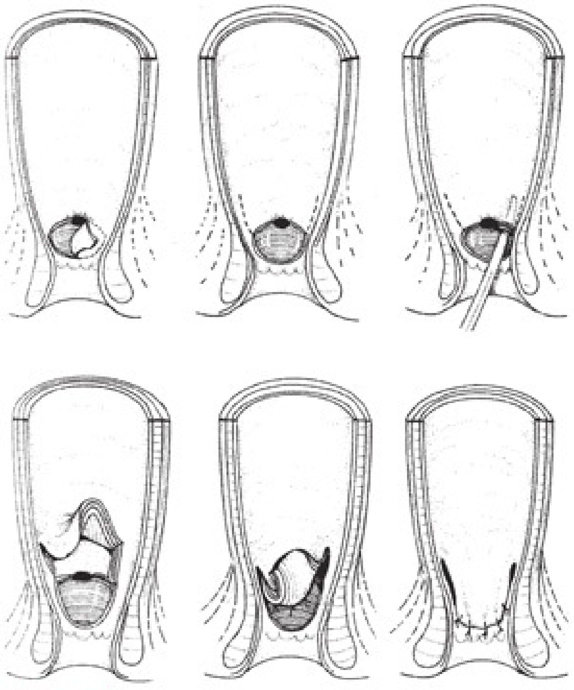

FIGURE 25.2 Through the anal canal, an ellipse of rectal mucosa is removed. A full-thickness U-shaped flap of rectal wall is elevated above the fistula. The full-thickness flap of rectal wall is brought down over the fistula and sutured in two layers to the rectal wall. (Reprinted with permission from Tiptaft RC, Motson RW, Costello AJ, et al. Fistulae involving rectum and urethra: the place of Parks' operations. *Br J Urol* 1983;55:711–715. Copyright © 2008, John Wiley and Sons.)

York–Mason Approach. Historically, this transanosphincteric approach has been the most widely used surgical approach for RUF repair, and the efficacy and success has been well established (34,35). This approach is best suited for small postsurgical fistulas that are too proximal to be treated by the transanal approach. Previous radiation or ablative therapy makes this approach less desirable because it limits the options for healthy tissue interposition.

The patient is placed in the prone jackknife position and the buttocks are separated with adhesive tape. An incision is made in the midline from the tip of the coccyx to the anal verge. The sphincter is divided in the midline after marking sutures are placed on each side to ensure precise reapproximation. The rectal mucosa is then opened along the entire length of the incision to expose the fistula tract (Fig. 25.3). The fistula tract is excised and the plane between the rectal wall and the urinary tract is dissected. The urethra and the rectum are then closed in multiple layers using absorbable suture followed by closure of the rectal mucosa and finally the sphincter. Avoidance of overlapping suture lines is done where possible. A Foley catheter is placed and left indwelling for 2 to 3 weeks. A voiding cystourethrogram confirms the absence of leak. Typically, the fecal incontinence rates are acceptably low if adequate attention is given to proper sphincteric closure.

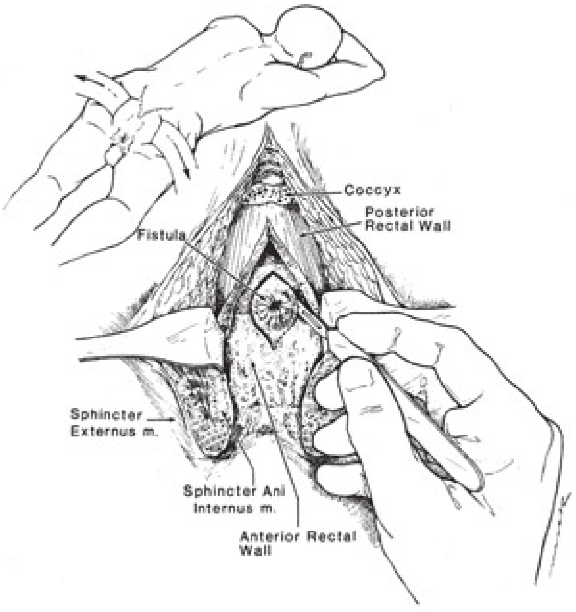

FIGURE 25.3 Posterior sagittal, transanorectal (York–Mason) approach for repair of rectourinary fistulas. The patient is placed in the prone jackknife position with tape used to displace the buttocks laterally. After division of the posterior anus and rectum, the fistula is easily identified with ample room for excision and repair. (Reprinted with permission from Stephenson RA, Middleton RG. Repair of rectourinary fistulas using a posterior sagittal transanal transrectal (modified York–Mason) approach: an update. *J Urol* 1996;155:1989–1991. Copyright © 1996 American Urological Association, Inc. Published by Elsevier Inc. All rights reserved.)

Surgical Approaches for Complex Rectourethral Fistulas

Presurgical evaluation of continence and functionality of the fecal and urinary systems as well as the functional class of the patient is necessary to determine the best treatment approach. We feel that complex rectourethral fistula repair with the goal of preservation of both fecal and urinary continence is best carried out through a transperineal approach. In the setting of adequate potential urinary function with a damaged anal sphincter, the transperineal approach with gracilis interposition is combined with an abdominal approach for permanent fecal diversion. In the setting of multiple complex fistulas or marked destruction of both the fecal and urinary systems, the abdominal approach with pelvic exenteration and supravesical diversion with permanent fecal diversion is preferred (36).

Our typical approach to a complex rectourethral fistula would involve three steps. First, an examination under anesthesia as described previously is conducted with placement of a suprapubic catheter and a fecal diversion. Often the fecal diversion can be done laparoscopically, decreasing the morbidity to the patient. Second, after 3 to 6 months of diversion, a transperineal repair with gracilis muscle interposition is performed. Concomitant urethral stricture can be addressed simultaneously with a transperineal approach with either an excision with primary reanastomosis or a buccal mucosa onlay graft. Finally, restoration of bowel continuity is staged to follow. A fourth step may be required to place an artificial urinary sphincter if urinary continence is compromised.

Transperineal Approach. The patient is first placed in the high lithotomy position. If possible, a urethral catheter is inserted. An inverted U incision is made in the perineum extending from one ischial tuberosity to the other and located just above the level of the anal sphincter (Fig. 25.4A). If needed, a short midline vertical limb can be added for exposure. After bluntly developing the ischiorectal space bilaterally, the perineal dissection begins in the plane between the anal sphincter and the bulbospongiosus muscle taking care to avoid injury to the sphincter mechanism if possible. The dissection is continued along the anterior surface of the rectum until the fistula is encountered. The rectum is sufficiently mobilized laterally into the perirectal fat to allow a tension-free closure of the fistula from the rectal side. The urethra and/or prostate if applicable are then dissected off of the rectum proximal to the fistula, and it is important to carry this dissection to near the level of the peritoneal reflection to aid closure of the rectum and secure placement of the gracilis flap. Assessment is made at this point of the degree of rectal injury as well as urethral injury (Fig. 25.4B). Flexible cystoscopy aids in localizing and planning the repair for the urethral side of the fistula. The rectum is closed in two layers with the assistance of the colorectal team. If buccal mucosa is required for closure of a large fixed urethral defect, graft harvest can be done during this time. The urethral defect is closed by suturing the buccal graft with absorbable suture. If the defect does not require grafting, it is closed primarily with interrupted absorbable suture. We typically use polydioxanone suture for its tensile strength, and make all attempts to keep the knots outside of the urothelium.

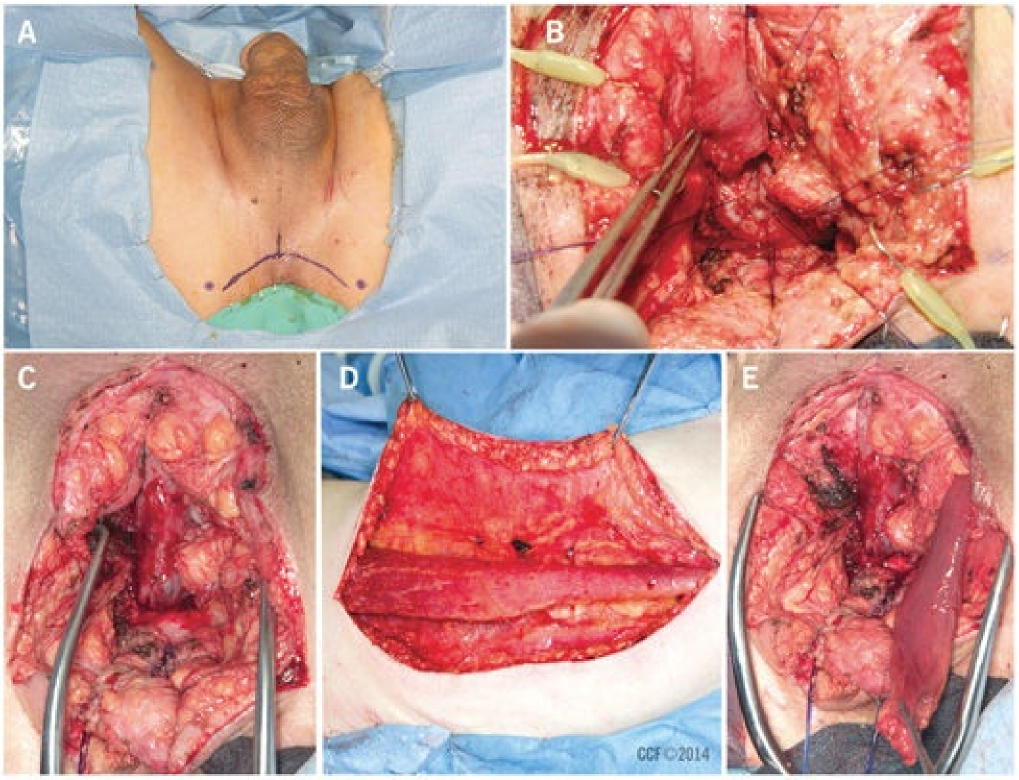

FIGURE 25.4 Transperineal repair with excision and primary anastomosis for urethral stricture. A: Positioning and skin incision. The ischial tuberosities are marked with dots. B: Anastomotic sutures in the prostatic urethra for anastomotic repair. C: Closure of the rectum and anastomosis of the urethra is complete. D: The gracilis muscle is isolated and taken off of its distal insertion. E: Gracilis is rotated into the wound as an interposition flap. (Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 2002–2014. All rights reserved.)

If an associated bulbomembranous urethral stricture is present, a urethrotomy incision may be initiated at the fistula site and extending through the membranous stricture and 1 cm into healthy urethra. The buccal mucosa graft is then laid into this entire defect. In the setting of a posterior urethral stricture and associated cavitation and tissue destruction, buccal mucosa onlay is not possible, and we then proceed with excision of the cavitated tissue (“partial prostatectomy”) to a level where the prostatic urethra or bladder neck appears to be sufficient to support an anastomotic repair. The distal urethra is then mobilized and the intercrural space developed to allow a tension free anastomosis to the proximal bulbar urethra (Fig. 25.4C).

Gracilis Interposition Flap. The gracilis muscle offers a versatile option for healthy tissue interposition in both the prone and lithotomy positions as first described by Ryan et al. (37) in 1979. The patient’s legs are lowered into a low lithotomy position, and a linear incision is made along the course of the gracilis muscle (Fig. 25.4D). The anatomic marker is the palpable adductor longus muscle, and the incision should be two fingerbreadths inferior to this line along its axis. The proximal sites of insertion of the gracilis tendon are the symphysis pubis, inferior pubic ramus, and ischium and the distal insertion is onto the medial condyle of the knee. The muscle is mobilized, taking care to preserve the primary vascular pedicle, which is derived primarily from the medial circumflex branch of the profunda femoral artery, although one to two other smaller pedicles may be encountered. The primary pedicle is usually located approximately 9 cm from the pubic tubercle. The muscle is released from its distal tendinous insertion and routed through a large tunnel into the perineal incision (Fig. 25.4E). It is interposed between the two repairs and sutured in place proximally and laterally with absorbable suture. Typically, there are minimal functional losses as the adducting function of the leg is maintained by the adductor magnus and adductor longus; however, it is our preference to harvest the left muscle if possible because it is less likely to interfere with the subsequent operation of a motor vehicle. Drains are left both in the perineum and along the gracilis harvest site.

In the setting of a simple RUF, a gracilis interposition may still be used at the discretion of the surgeon if the repair seems to be tenuous for some reason. Alternatively, a flap of scrotal dartos can be rotated into the defect to serve as an interposition in selected patients (38).

Transabdominal Approach. The transabdominal approach may be used in the setting of a diseased rectum and a higher order fistula to the bladder neck or posterior bladder. It provides good exposure to a proximal fistula and allows simultaneous permanent colostomy as well as access to omentum or the rectus muscle for use as interposition flaps. The abdominal approach is not well suited for fistulas to the urethra because access via the pelvis is limited.

Although some have demonstrated the feasibility of transperitoneal laparoscopic repair in select cases of RUF because it may facilitate simultaneous colostomy and interposition, efficacy data is limited compared to more conventional methods.

Abdominoperineal Approach. In the setting of severe damage to the rectum and a preserved anal sphincter as may be seen at times following radiation therapy, repair of the rectal side of the RUF may not be possible. In this situation, proctectomy with a staged Turnbull–Cutait coloanal pull through procedure may be feasible with the goal of preserving fecal continence and function as well as urinary function. The proctectomy in combination with urethral repair is done in the prone jackknife position followed by repositioning the patient supine for laparotomy and coloanal pull through. Rotation of the sigmoid mesentery anteriorly during the pull through can provide coverage for the urethral repair or a buccal graft when needed.

Outcomes

There is a high degree of fistula closure and preservation of urinary and bowel continuity and function even in complex cases of RUF following transperineal repair with gracilis muscle interposition. Mild urinary incontinence is a common occurrence, and more clinical significant incontinence occurs in 12% to 16% (15,16,28) and can be managed with a staged artificial urinary sphincter implantation staged 6 to 12 months after the repair. Recurrent urethral stricture or bladder neck contracture can occur in 10% to 25% (21,28) and is typically managed endoscopically. Subsequent permanent urinary diversion may be required in up to 10% (15). Fecal incontinence rates range from 8% to 23% (16,39), and permanent diversion is necessary in 16% to 31% (15,16). Quality of life outcomes tend to be acceptable, and fecal outcome measures are typically better than urinary (39).

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CHAPTER 26 VESICAL TRAUMA AND HEMORRHAGE

CHAD M. GRIDLEY AND CHRISTOPHER D. MCCLUNG

BLADDER TRAUMA

Trauma is the most common cause of bladder injury; however, only 1.6% of trauma victims will have a bladder laceration (1). Blunt trauma, such as high-impact motor vehicle collisions or falls, is the cause of 80% to 85% of bladder injuries (2–4). The mechanisms through which these injuries typically occur are either by a direct blow to the abdomen with a full bladder (classically causing rupture at the dome) or by an injury associated with a pelvic fracture. Pelvic fracture is associated with 80% of bladder injuries and accounts for almost all extraperitoneal injuries (3). These fracture-related injuries occur due to shearing from disruption of fascial attachments to the bladder or due to direct lacerations by bone fragments. The latter is more rare. Penetrating injuries to the bladder are less common in the civilian literature. Bladder injury has been cited to be present in 3.6% of abdominal gunshot wounds, 13% of penetrating injuries to the rectum, and 20% of penetrating injuries to the buttocks (5–8). The bladder can also be injured iatrogenically. Common iatrogenic causes include gynecologic surgery (52% to 61%), urologic surgery (12% to 39%), and general surgical procedures (9% to 26%) (9,10).

Presentation and Diagnosis

In the classical clinical presentation of a bladder injury, patients complain of suprapubic fullness and an inability to void. Hematuria is the hallmark of a bladder laceration. Swelling of the perineum and scrotum is also common when significant urinary extravasation or pelvic bleeding has occurred. Gross hematuria is present in 95% of patients.

According to the 2004 consensus statement on bladder injuries, the absolute indication for bladder imaging is a pelvic fracture associated with gross hematuria (11). Relative indications for imaging include clinical situations where there is a high index of suspicion of bladder injury. These include microscopic hematuria associated with a pelvic fracture and gross hematuria without a pelvic fracture. Specific pelvic fracture patterns have been shown to be predictive of injury. In a review of 37 patients, Avey et al. (12) showed that pubic symphysis diastasis and obturator ring fractures with displacement greater than 1 cm were predictors of bladder laceration. Acetabular fractures were not predictive of injury.

Static and computerized tomography (CT) cystography are the current studies recommended to diagnose bladder injuries. A recent study showed that noncontrast CT scan failed to detect or misdiagnosed the location of bladder injuries in 13% of patients (13). Although both static and CT cystography have equal sensitivities and specificities, a CT cystogram is the most common test performed in modern trauma centers. Patients with bladder trauma generally have coexisting injuries requiring a CT scan for other reasons. A CT cystogram can be performed quickly in this clinical situation where many centers have CT scanners in close proximity to the trauma bay. The sensitivity and specificity of CT cystography to detect bladder injury are 95% and 100%, respectively. Furthermore, CT cystography has the ability to determine the location of the bladder laceration with 82% accuracy (14). If static cystography is performed, it is important to obtain drainage phase images because up to 10% of lacerations can be missed if these images are not taken (15). Drainage phase images are not required for CT cystography.

Static and CT cystography require a Foley catheter for imaging. It is important to remember that 10% to 29% of bladder injuries will have a coexisting urethral injury (16). If blood at the meatus is present on initial exam, the urethra should be assessed with a retrograde urethrogram prior to inserting the catheter. Once the urethra is cleared, a Foley catheter may be placed. The bladder is then filled under gravity in a retrograde fashion through the Foley catheter with 350 mL of contrast in an intubated patient or until tolerated in an awake patient. Capping the Foley catheter and allowing renal secretion of intravenous (IV) contrast to fill the bladder is not an appropriate way to perform bladder imaging (17).

The initial diagnostic element is to define the location of injury: extraperitoneal (EP), intraperitoneal (IP), or both. These occur with frequencies of 60%, 30%, and 10%, respectively (2,4,15). The hallmark of an IP injury is the presence of contrast that outlines loop of bowel (Fig. 26.1). Isolated EP injuries have no communication with the peritoneum and will classically have a “flame” or “molar tooth” appearance on imaging (Fig. 26.2). A fine diagnostic detail is to assess the status of the bladder neck. Bladder neck lacerations can be seen as areas of extravasation low on the bladder near the Foley balloon (Fig. 26.3).

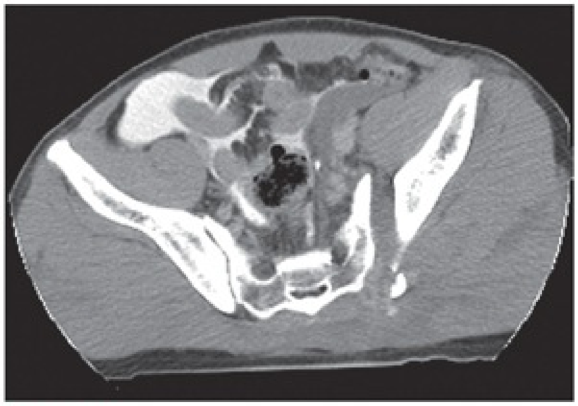

FIGURE 26.1 A CT cystogram demonstrating an IP injury with contrast outlining loops of bowel.

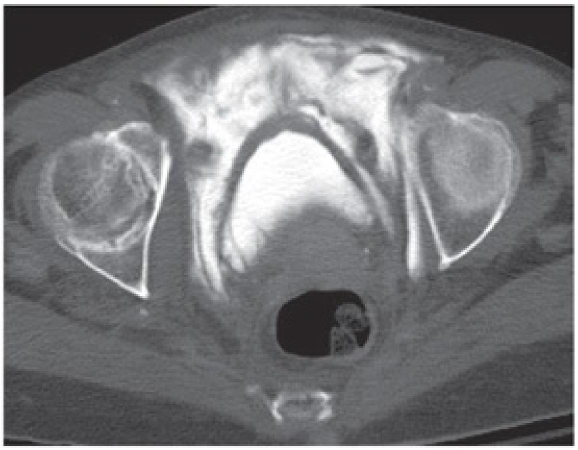

FIGURE 26.2 A CT cystogram revealing an EP injury. This image depicts the “molar tooth” sign common in many EP injuries.

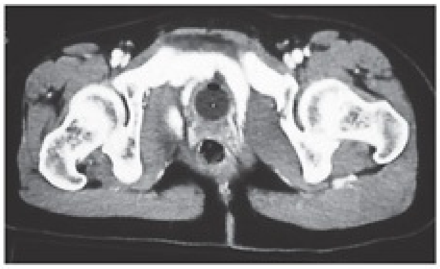

FIGURE 26.3 A CT cystogram image imaging revealing a bladder neck injury, with contrast extravasation at the bladder neck.

The American Association for the Surgery of Trauma (AAST) has established a grading system for organ injuries due to trauma. Most urologists are familiar with this grading system for renal trauma, but they are less familiar with the system for bladder trauma. In brief, the AAST grades injuries on a scale from 1 to 5, with grade I being a low-grade injury and V being a severe injury. This scale is shown in Table 26.1. The classification becomes easy to remember if one thinks of contusions or small EP lacerations as low-grade injuries and combined EP/IP injuries or bladder neck lacerations as high grade.

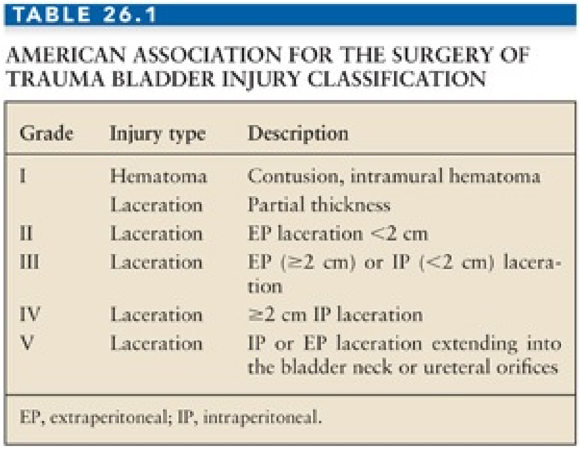

TABLE 26.1

AMERICAN ASSOCIATION FOR THE SURGERY OF TRAUMA BLADDER INJURY CLASSIFICATION

Grade	Injury type	Description
I	Hematoma	Contusion, intramural hematoma
	Laceration	Partial thickness
II	Laceration	EP laceration <2 cm
III	Laceration	EP (≥2 cm) or IP (<2 cm) laceration
IV	Laceration	≥2 cm IP laceration
V	Laceration	IP or EP laceration extending into the bladder neck or ureteral orifices

EP, extraperitoneal; IP, intraperitoneal.

Management

The management of bladder lacerations depends on injury location. The two options are conservative management with Foley catheter alone or primary surgical repair (cystorrhaphy). In general, EP injuries without bladder neck involvement may be managed with a Foley catheter alone. Healing occurs within 10 to 14 days in 74% of cases, and almost all heal within 3 weeks (18,19). However, complications have been cited to occur such as delayed healing, vesicocutaneous fistula formation, septic events, and bladder calculi (18). Prior research does suggest that complications are lower for EP lacerations repaired primarily relative to conservative management with a Foley catheter alone (19).

IP injuries and bladder neck injuries require formal surgical repair. Although bladder neck injuries are by definition EP, resolution with Foley catheter alone is marginal at best. Persistent leaks are common in this situation.

Penetrating injuries should be managed with exploration. These patients are commonly explored for nonurologic indications to manage other injuries because up to 80% of penetrating bladder injuries also have gastrointestinal injuries. Concomitant rectal and bladder injuries can result in fistula formation if not surgically repaired. Repair is encouraged in this setting along with the use of an omental flap as tissue interposition to avoid overlapping suture lines between bladder and rectal repairs. In the largest penetrating lower urinary tract study to date, 90% of patients had dual entrance and exit wounds (20). All lacerations should be repaired, and gastrointestinal injuries should be addressed.

A unique consideration is the coexisting vaginal laceration and bladder laceration. All female patients presenting with a pelvic fracture require a manual vaginal exam to rule out vaginal laceration and open pelvic fracture. If not surgically addressed, hematoma infection and fistula formation may occur (21). The bladder and vagina require suture repair. As with rectal injuries, the use of an omental flap for tissue interposition between the bladder laceration and vaginal laceration repair sites is suggested.

Surgical repair of bladder lacerations should be done during the index admission. If the patient is having exploratory laparotomy shortly after admission for other intra-abdominal injuries and is hemodynamically stable, the repair should be done at this time. A trauma patient will not infrequently require resuscitation and pelvic angioembolization for pelvic bleeding immediately after presentation. In this setting, resuscitation takes precedent, and surgical repair should be done as soon as the patient is hemodynamically stable.

Cystorrhaphy can be accomplished by two separate approaches: transabdominally or retropubically. In an acute setting, the benefit of a transabdominal approach is to avoid a pelvic hematoma associated with a pelvic fracture. The space of Retzius should not be opened in this situation because significant bleeding can ensue. EP and bladder neck lacerations can be repaired from within the bladder through an abdominal incision.

Primary surgical closure of EP repairs is most commonly done at the time of open reduction and internal fixation of a pelvic fracture. This commonly occurs several days after admission when the patient has been resuscitated and bleeding has resolved. It is the authors’ practice to repair all EP injuries primarily at the time of open reduction and internal fixation for the pelvic fracture. Although more studies are needed to document superiority of primary suture repair over conservative management with a Foley for EP injuries, older data does suggest that complication rates are higher with Foley treatment alone (19).

In summary, EP lacerations may be managed solely with Foley catheter decompression. Indications for open surgical repair are the following:

1. IP bladder rupture
2. Bladder neck laceration
3. Penetrating bladder injury
4. Inadequate drainage with a Foley catheter
5. Concomitant rectal or vaginal injury
6. Hemodynamic stability and undergoing laparotomy for other indications
7. EP repair at time of open fixation for a pelvic fracture

Rarer indications for surgical intervention include the presence of bone fragments protruding into the bladder and bladder entrapment into a pelvic fracture site. Bladder entrapment into a pelvic fracture site can occur during the injury itself, or at the time of internal or external fixation of the pelvis (22,23). Failure to treat these early after injury can result in persistent urinary leaks, lower urinary tract symptoms, and dyspareunia (24). Examples of radiographic and intraoperative findings of bladder entrapment after pelvic fracture are shown in Figures 26.4 and 26.5.

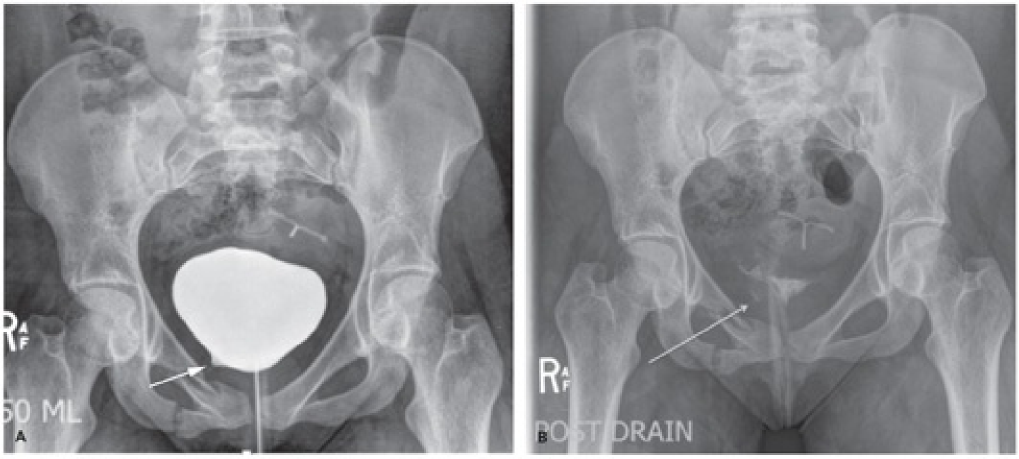

FIGURE 26.4 A: The filling phase of a static cystogram in a patient with bladder entrapment from a pelvic fracture. The *arrow* demonstrates the site of bladder entrapment. B: The drainage phase of a static cystogram in a patient with bladder entrapment from a pelvic fracture. The *arrow* demonstrates the site of persistent extravasation.

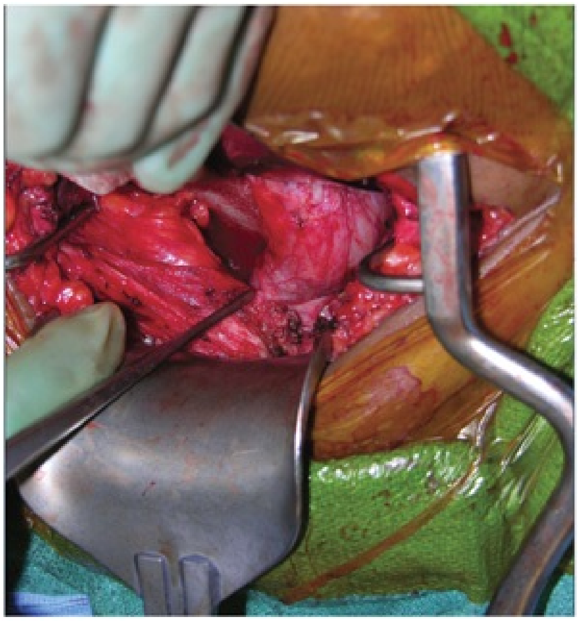

FIGURE 26.5 Intraoperative findings on the patient in Figure 26.4. The forceps are pointing toward the site of bladder entrapment.

Description of Repair

Transabdominal (Fig. 26.6A and B): A vertical, midline incision is made. The skin and rectus fascia are opened. The peritoneum is entered. Urine and abdominal fluid are evacuated. The abdominal is serially examined to rule out other organ injuries. The location of the IP laceration is identified, and the bladder is evacuated of any residual hematoma. Bony spicules, if present, are removed at this time. The bladder is thoroughly investigated transvesically through the laceration. If the laceration is small, the cystotomy is extended to improve visualization. The presence of concomitant EP lacerations and bladder neck injuries are ruled out. If nonviable tissue is present, laceration edges are gently debrided. Exposure of the bladder neck can be facilitated with the use of a long nose nasal speculum. If a bladder neck laceration is present, it is repaired with interrupted 2-0 polyglycolic acid sutures from within the bladder. If a separate EP injury is identified, it is repaired in two layers with a running 3-0 polyglycolic acid suture from within the bladder. During the acute setting of a pelvic fracture, it is important to do repairs within the bladder and to avoid the space of Retzius. Opening up the space of Retzius will disturb the pelvic hematoma and significant bleeding may follow.

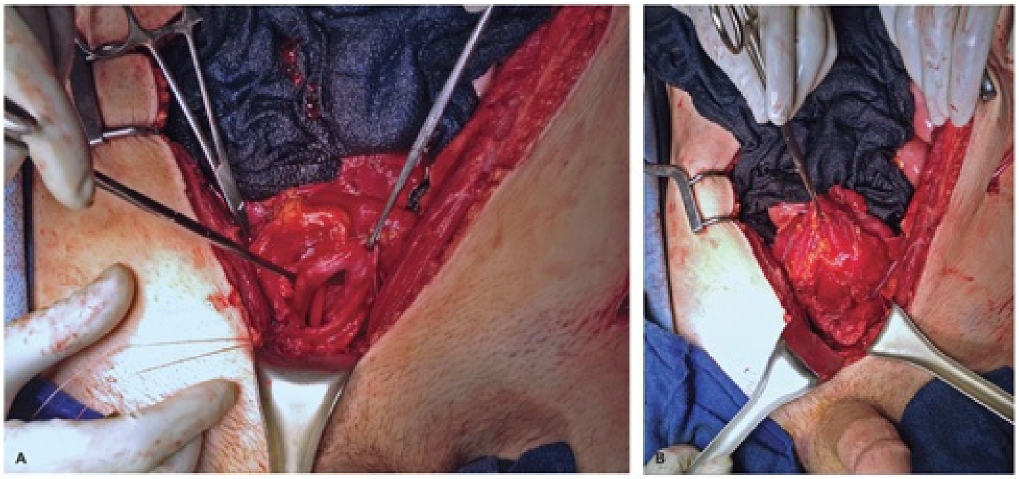

FIGURE 26.6 A: Intraoperative finding of a combined EP and IP bladder laceration. B: Image after cystorrhaphy of the same patient in Figure 26.6A. (Images courtesy of Thomas Smith, MD, Baylor College of Medicine.)

The ureteral orifices are systematically identified. If no efflux of urine is seen or if bloody efflux is present, the ureters are explored to rule out a concomitant ureteral injury. The management of ureteral injuries is described elsewhere within this text.

Once the transvesical investigation is complete, nonviable edges of the IP laceration are debrided, and the bladder is closed in two layers. The mucosal layer is closed with a running 3-0 polyglycolic acid suture, and the muscular layer is closed with a running 3-0 polyglycolic acid suture. Placement of a suprapubic tube is not required. Small case series have shown no benefit to leaving a suprapubic tube in addition to a Foley catheter (25,26). The bladder is filled through the Foley with sterile saline to assess the watertightness of closure, and interrupted sutures are placed to insure watertightness of closure if needed. Drains are generally not necessary but may be used for the tenuous repair. The abdominal contents are irrigated with copious amounts of saline. The abdomen and skin are closed in routine fashion.

Extraperitoneal Repair

Most orthopedic surgeons use a Pfannenstiel incision to accomplish an open reduction and internal fixation of the pelvis. If other abdominal urologic surgery is required, or if an abdominal washout is required for IP repair, the authors advise the urologist to discuss the plans with the orthopedic team prior to surgery. A mutually beneficial midline incision can be used. In general, primary bladder repair for EP injuries can be amply managed through a Pfannenstiel incision.

After completion of the open reduction and internal fixation per orthopedics, the bladder is exposed within the space of Retzius. After repair of pelvic fractures, the bleeding from the fracture site is minimal to nonexistent. The laceration is identified, and the bladder is explored through the laceration as described earlier. The lacerated edges are minimally debrided, and the bladder is closed in two layers. The mucosal layer is closed with a running 3-0 polyglycolic acid suture, and the muscular layer is closed with a running 3-0 polyglycolic acid suture. A suprapubic tube is not necessary. The fascia and skin are then closed in standard fashion.

Postoperative Care

A static cystogram is obtained 7 to 10 days after cystorrhaphy. If no evidence of extravasation is seen, the Foley catheter may be removed. It is the authors' preference to perform a static cystogram over CT cystography to prevent unneeded radiation exposure. Although most practitioners perform postoperative imaging, recent evidence suggests that routine imaging may not be necessary. In a recent case series of 127 patients, only 1 patient had persistent extravasation on postoperative imaging (27). This was a patient with a complex trigone injury requiring ureteral reimplantation. From this work, the authors concluded that postoperative imaging is not required for simple or low-grade injuries.

Complications

In general, complications are rare after primary suture repair of bladder injuries. In one large series, no urologic complications were cited after primary closure of the bladder (18). Complications that are cited to occur include hematuria with clot retention, sepsis, urinary urgency, and urinary frequency (19).

Complications are more common in patients with an EP rupture managed with a Foley catheter alone. In a review of a 10-year experience in managing bladder lacerations, Kotkin and Koch (18) cited a 26% complication rate in EP lacerations managed with Foley catheter alone. Cited complications included persistent extravasation on imaging, bladder calculi, pseudodiverticulum formation, pelvic hematoma infection, sepsis, and death (18,19).

VESICAL HEMORRHAGE

Significant bleeding from the bladder can occur in the absence of trauma. The most common cause of refractory hematuria is hemorrhagic cystitis (HC). HC is defined by diffuse inflammation to the bladder causing bleeding from the mucosa. This can be a significant challenge for the urologist to manage. The causes of HC include infection (viral and bacterial), chemical exposure (including chemotherapy), and pelvic radiation. The possible etiologic factors for HC are listed in Table 26.2.

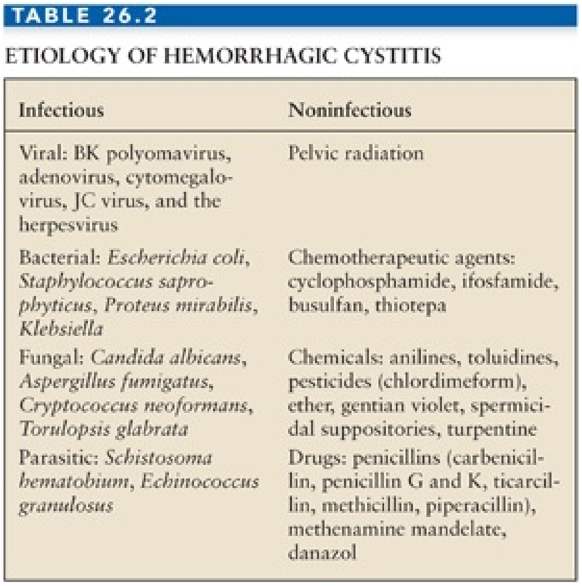

TABLE 26.2

ETIOLOGY OF HEMORRHAGIC CYSTITIS

Infectious	Noninfectious
Viral: BK polyomavirus, adenovirus, cytomegalovirus, JC virus, and the herpesvirus	Pelvic radiation
Bacterial: *Escherichia coli*, *Staphylococcus saprophyticus*, *Proteus mirabilis*, *Klebsiella*	Chemotherapeutic agents: cyclophosphamide, ifosfamide, busulfan, thiotepa
Fungal: *Candida albicans*, *Aspergillus fumigatus*, *Cryptococcus neoformans*, *Torulopsis glabrata*	Chemicals: anilines, toluidines, pesticides (chlordimeform), ether, gentian violet, spermicidal suppositories, turpentine
Parasitic: *Schistosoma hematobium*, *Echinococcus granulosus*	Drugs: penicillins (carbenicillin, penicillin G and K, ticarcillin, methicillin, piperacillin), methenamine mandelate, danazol

Bacterial infections are the most common cause of HC. Due to the effectiveness of antibiotic therapy, refractory hemorrhage is rarely seen and the disease has a limited course after treatment with appropriate antibiotics. The most common organisms associated with bacterial HC include *Escherichia coli*, *Staphylococcus saprophyticus*, *Proteus mirabilis*, and *Klebsiella* (28). Fungal organisms that have been cited to cause HC include *Candida albicans*, *Cryptococcus neoformans*, *Aspergillus fumigatus*, and *Torulopsis glabrata* (28). Viral infections are a less common cause of HC and are more common in children and immunosuppressed adults. Specific viral etiologies include the

BK polyomavirus, adenovirus, cytomegalovirus, JC virus, and the herpesvirus (29).

Unlike the limited course of bacterial induced HC, other etiologies can have a chronic course. The most common cause of chronic HC is due to use of chemotherapeutic oxazaphosphorines (30). Included within this class of medications are cyclophosphamide and ifosfamide. Acrolein, a liver metabolite of oxazaphosphorines, is the principal inciting agent and acts by direct contact with the bladder mucosa. It is thought to have a pathologic affect by increasing intracellular reactive oxygen, nitrogen species, and proinflammatory cytokines (31). Histologic changes that occur in the bladder are similar to those seen with radiation and include edema, ulceration, neovascularization, hemorrhage, and necrosis. Animal studies have shown that direct cytotoxic effects occur as early as 2 hours after exposure (32). The incidence of cyclophosphamide-associated HC ranges from 2% to 40%, with mortality rates as high as 4% (30). Busulfan and thiotepa are also associated with HC (30). HC is dose-dependent and related to the route of administration of the chemotherapeutic agent (higher with IV administration). Furthermore, it is more severe in dehydrated patients. Efforts to prevent the development of agents causing acrolein-induced HC have focused on expedient bladder drainage (with or without a Foley catheter), hydration, and the use of medications to inhibit direct acrolein cytotoxicity (mesna and Mucomyst) (33). Current research suggests that none of these treatment options are clearly superior to one another (34,35).

Radiation therapy to the prostate, bladder, or other pelvic organs can result in HC. This can occur as late as 10 years after radiotherapy. The median time to development of HC after radiation therapy is 4 years (35,36). Initially, there is mucosal edema with submucosal hemorrhage. In the long term, radiation causes progressive endarteritis whereby tissue becomes hypoxic. The urothelium is then unable to replace collagen and normal cellular loss resulting in eventual tissue breakdown (37).

A wide range of drugs and industrial toxins can also give rise to HC. The most common are aniline dyes. Conservative treatment with adequate hydration, bladder irrigation, and removal of the causative agent will suffice as treatment in most cases.

Management of Hemorrhagic Cystitis

A practical list and algorithm for the management of HC is outlined in Table 26.3 and Figure 26.7. Initial attempts at treating significant HC should be focused on patient presentation and clinical symptoms. If the patient is significantly anemic, tachycardiac, and hypotensive, IV hydration should be started immediately, and blood transfusions should be given as indicated. If the patient is in clot retention, a large (24Fr) three-way catheter should be placed. The patient's bladder should then be manually irrigated until free of clots and continuous bladder irrigation then started. If the patient denies passing clots, is able to void, and is not severely anemic, conservative management with hydration alone is not unreasonable. If the cause of hematuria is thought to be of infectious etiology, treat with appropriate antibiotic therapy as indicated.

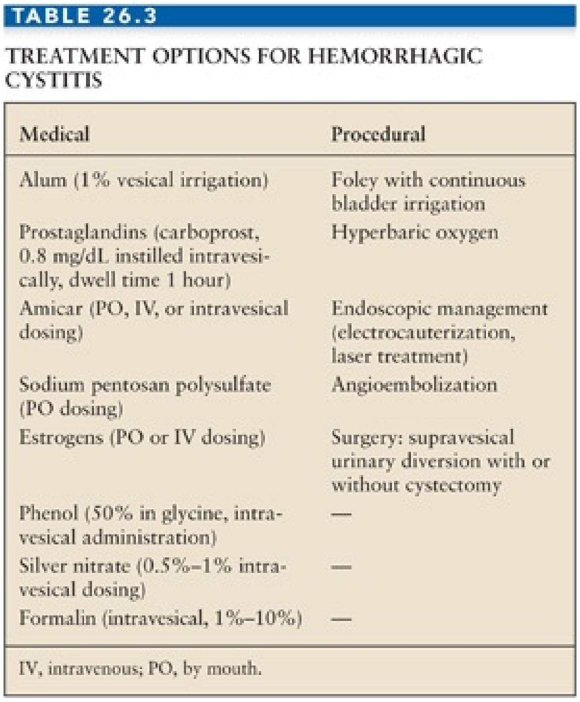

TABLE 26.3

TREATMENT OPTIONS FOR HEMORRHAGIC CYSTITIS

Medical	Procedural
Alum (1% vesical irrigation)	Foley with continuous bladder irrigation
Prostaglandins (carboprost, 0.8 mg/dL instilled intravesically, dwell time 1 hour)	Hyperbaric oxygen
Amicar (PO, IV, or intravesical dosing)	Endoscopic management (electrocauterization, laser treatment)
Sodium pentosan polysulfate (PO dosing)	Angioembolization
Estrogens (PO or IV dosing)	Surgery: supravesical urinary diversion with or without cystectomy
Phenol (50% in glycine, intravesical administration)	—
Silver nitrate (0.5%–1% intravesical dosing)	—
Formalin (intravesical, 1%–10%)	—

IV, intravenous; PO, by mouth.

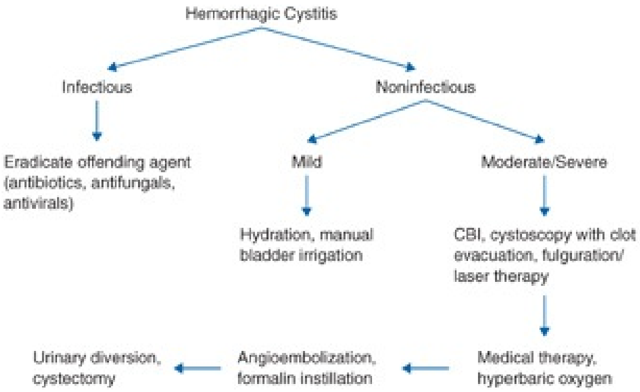
Hemorrhagic Cystitis
Infectious
Noninfectious
Eradicate offending agent (antibiotics, antifungals, antivirals)
Mild
Moderate/Severe
Hydration, manual bladder irrigation
CBI, cystoscopy with clot evacuation, fulguration/ laser therapy
Medical therapy, hyperbaric oxygen
Angioembolization, formalin instillation
Urinary diversion, cystectomy

FIGURE 26.7 Algorithm for the treatment of HC.

Moderate hematuria can be treated with continuous saline irrigation through a three-way Foley catheter. If the hematuria fails to resolve, endoscopic management of HC can be attempted. Various methods have been used to control bleeding. These methods include electrocauterization, Nd:YAG laser coagulation, green light KTP laser, and 980-nm diode lasers (38–40).

If hematuria persists, intravesical medications can be given with or without the use of continuous bladder irrigation (CBI). One percent alum (potassium or ammonium aluminum sulfate) is often used in this situation. The alum acts as an astringent and precipitates the surface proteins. The bladder should be completely irrigated free of clots prior to starting alum because gelatinous clots can be difficult to irrigate after therapy has begun. Aluminum levels must be monitored, particularly in patients with renal insufficiency. Severe acidosis and encephalopathy can occur in such patients as a result of high aluminum levels.

Another intravesical agent that has been used for HC is the periodic installation of prostaglandins (PGE_2, $PGF_{2\alpha}$) and $PGF_{2\alpha}$ analogs (carboprost) (41–43). Although the exact mechanism by which these work is unknown, they are thought to cause smooth muscle contraction of the blood vessels in the mucosa or submucosa as well as to cause platelet aggregation (44). They can be used prophylactically or therapeutically. PGE_2 has been used in a dose of 0.75 mg in 200 mL of normal saline instilled for 4 hours. The effective dose of $PGF_{2\alpha}$ has been 1.4 mg in 200 mL of normal saline. Carboprost has been used in a dose of 0.8 mg per dL diluted in normal saline and instilled for 1 hour at 6-hour intervals; good results occurred in 62% of patients in one study (43).

Intravesical instillation of silver nitrate (0.5% to 1% solution) for short periods of time (10 to 20 minutes) followed by saline irrigation of the bladder to remove residual silver nitrate is also an effective technique. Reflux should be ruled out by cystography prior to dosing with silver nitrate because upper tract obstruction may occur (45). Instillation of silver nitrate is painful and should be conducted under anesthesia.

E-aminocaproic acid (Amicar) can be given orally, parenterally, or intravesically by CBI. Amicar prevents the activation of plasminogen to plasmin, inhibiting fibrinolysis. It is now U.S. Food and Drug Administration–approved for the use of refractory hematuria. Caution should be used when dosing this medication because thromboembolic complications may occur. It is contraindicated in patients with thromboembolic disorders such as coronary artery disease, history of ischemic strokes, and deep vein thromboses. When used, it does appear to be efficacious. In a case series of 37 patients, Singh and Laungani (46) reported a success rate of 92%.

Sodium pentosan polysulfate (SPPS), a semisynthetic polysaccharide, has been studied as an agent in the treatment of HC secondary to radiation. SPPS replaces the surface glycosaminoglycans that have been injured. In a review of 14 patients, Hampson and Woodhouse (47) reported a complete or partial response in 79% of patients.

Estrogens are believe to control hematuria by strengthening the capillary walls within the mucosa of the bladder (48). They have been used to treat HC secondary to radiation and cyclophosphamide exposure. Conjugated estrogens can be administered through oral or IV routes. Success rates vary between 60% and 80% (49).

Phenol has been used to treat HC (50). Phenol is instilled in a dose of 30 mL of a 100% solution mixed with an equal volume of glycine for a dwell time of 1 minute. The solution is washed out with 95% ethanol (60 mL) and saline to prevent methemoglobinemia. Limited data exists in the literature to compare it efficacy to other known treatments.

Hyperbaric oxygen (HBO) therapy has been demonstrated to show efficacy in treating radiation-induced HC (5). HBO therapy is believed to promote angiogenesis at the site of the irradiated tissues through an increased oxygen gradient (37). The usual course of HBO treatment includes 100% oxygen levels at 2 to 2.5 atm of pressure, 5 days a week for a total of 30 treatment sessions. Complete response rates range between 59% and 96%, with relapse rates of 16% to 24% (36,51–54).

Persistent severe hemorrhage that has not subsided despite the aforementioned measures can be treated with intravesical instillation of 1% formalin. Formalin fixes bladder mucosa through protein cross-linking. Due to defunctionalization of the bladder, this is reserved as a last resort. As formalin instillation is painful, general anesthesia is required. It is necessary to first rule out vesicoureteral reflux by performing a cystogram before using formalin because it can cause fibrosis and scarring of the ureters and renal pelvis. If need be, the ureters can be occluded with Fogarty balloon catheters to prevent reflux while formalin is instilled. Fifty milliliters of 1% formalin (0.37% formaldehyde) diluted with saline should be instilled for 4 to 10 minutes. This should then be washed out with saline, and the saline irrigation continued for 24 hours. The external genitalia are covered with towels or Vaseline to prevent irritation. Formalin instillation may be repeated, and dose escalations up to a concentration of 10% have been documented. Success rates in radiation-induced HC range between 75% and 89%, with relapse rates in 23% (55,56).

Open ligation of the hypogastric arteries is rarely performed in the modern era. Embolization of the hypogastric arteries with autologous clot, gel foam, coils, or ethanol via interventional radiologic techniques is more common and has evolved over time. Originally, these were “nonselective” because both internal iliac arteries were embolized. Nonselective embolization not uncommonly resulted in temporary gluteal claudication. However, selective embolization of the vesical arteries is now possible, with significantly less complications. Based on the present authors’ review, 13 cases of superselective angioembolization for HC have been published in the literature. Durable success was achieved in 11 patients in the follow-up period. Bilateral embolization was required for complete resolution in all cases (57–59).

Supravesical diversion is the last resort in the management of HC. The goal of supravesical diversion is to divert urokinase away from the lower urinary tract. This can be accomplished by the following techniques: nephrostomy tube placement with ureteral occlusion, cystotomy with externalized ureteral catheters, cutaneous ureterostomies, and formal diversion with an ileal conduit. In general, the complication rates are high when diversions are done without a cystectomy. In a series of 40 patients who had diversions without a cystectomy, 80% had bladder-related complications (60). A cystectomy should be strongly considered if a urinary diversion is performed.

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CHAPTER 27 INTERSTITIAL CYSTITIS/BLADDER PAIN SYNDROME

MICHAEL J. EHLERT AND KENNETH M. PETERS

Interstitial cystitis/bladder pain syndrome (IC/BPS) is a chronic, unrelenting condition with considerable morbidity. The symptoms were first described in the early 20th century associated with a distinct ulcer within the bladder (1). IC/BPS continues to be one of the most commonly missed diagnoses in urology (2). Patients are often seen by multiple providers and offered outdated and ineffective treatments for years. Recently, the evolution of thought around this condition and how to best treat it has changed from primarily bladder-centered to one of systemic neurosensitization often resulting in pelvic floor spasm leading to a voiding and pain syndrome. It is imperative that the patient complaining of IC/BPS symptoms is carefully phenotyped to determine the best mode of treatment. This chapter will describe various procedures to improve the symptoms of voiding dysfunction and pelvic pain.

Although the etiology of IC/BPS has not been clearly identified, much more is now known about its characteristics and natural history. The presentation may be variable; however, the more common symptoms are urinary frequency, urgency, and pelvic pain. Until recently, IC/BPS has been considered a disease predominantly affecting women; however, more men are now being diagnosed with this disease (3). Men presenting with symptoms of genital or perineal pain, frequency, or dysuria are often labeled as having chronic, abacterial prostatitis; in fact, many of them suffer from IC/BPS. The astute clinician should aim to accurately diagnose this condition and offer treatments which have shown benefit to alleviate the most bothersome symptoms for each patient.

DIAGNOSIS

Because patient presentation and symptoms vary widely, all other etiologies must be excluded. The most worrisome would be that of a malignancy or other systemic condition for which treatment would be needed. IC/BPS thus remains a diagnosis of exclusion. Investigations should routinely be directed to exclude bacterial cystitis, neurogenic and nonneurogenic overactive bladder (OAB), endometriosis, bladder cancer, urethral diverticulum, and pelvic floor dysfunction. Defining IC/BPS has been extremely controversial, and to date, there remains considerable disagreement among experts. In 1987 and 1988, the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) developed a research definition for IC/BPS in order to provide homogenous groups of patients that may be compared to one another in clinical studies. However, experts in female urology and urogynecology have found this definition to be far too restrictive, and as many as 60% of patients with IC/BPS were being excluded (2). According to the International Continence Society, IC/BPS should be suspected in anyone with symptoms of suprapubic pain related to bladder filling, accompanied by urinary frequency and urgency, in the absence of urinary infection or other pathology (4). A similar definition was adopted by the American Urological Association (AUA) in their recent guidelines, although a more general “unpleasant sensation (pain, pressure, discomfort)” relating to the bladder was included (5). The European Society for the Study of IC/BPS (ESSIC) has developed specific diagnostic criteria that are based on a combination of urinary symptoms and bladder findings during cystoscopic evaluation. Although the vague inclusion criteria and overlapping taxonomy may be confusing, treatment should generally be directed toward the patient’s symptoms and any other coexisting conditions. Epidemiologic studies have shown increased rates of irritable bowel syndrome, fibromyalgia, migraine headaches, and anxiety (6).

Symptoms of IC/BPS are extremely variable and may present as mild irritative symptoms to severe symptoms refractory to all standard therapies. Acknowledging and treating the disease early often leads to rapid improvement in symptoms; thus, recognizing IC/BPS early so that therapy can be initiated is extremely important.

The diagnosis of IC/BPS begins with a complete and thorough history. Onset of symptoms may be days, weeks, or even months. Often patients have been clinically diagnosed with urinary tract infections despite negative cultures. Other misdiagnoses include endometriosis, fibroids, or other pelvic disorders, and some have even undergone surgery for them (7). A full dietary and fluid history is useful, as certain foods and drinks may exacerbate IC/BPS symptoms (8). A voiding diary provides objective evidence of daytime and nighttime frequency, and pain symptoms can be recorded with these as well. Baseline and sequential voiding diaries and symptom questionnaires allow one to determine the impact of various treatments for IC/BPS. The O’Leary-Sant Interstitial Cystitis Symptoms Index/Interstitial Cystitis Problem Index (ICSI/ICPI) and Pain, Urgency, Frequency scales (PUF) are commonly used (Table 27.1). For the pain component, a 10-point visual analog scale (VAS) and brief descriptor of pain location and quality is often all that is needed. It must be emphasized that these questionnaires assess baseline symptoms and treatment response but do not diagnose IC/BPS per se.

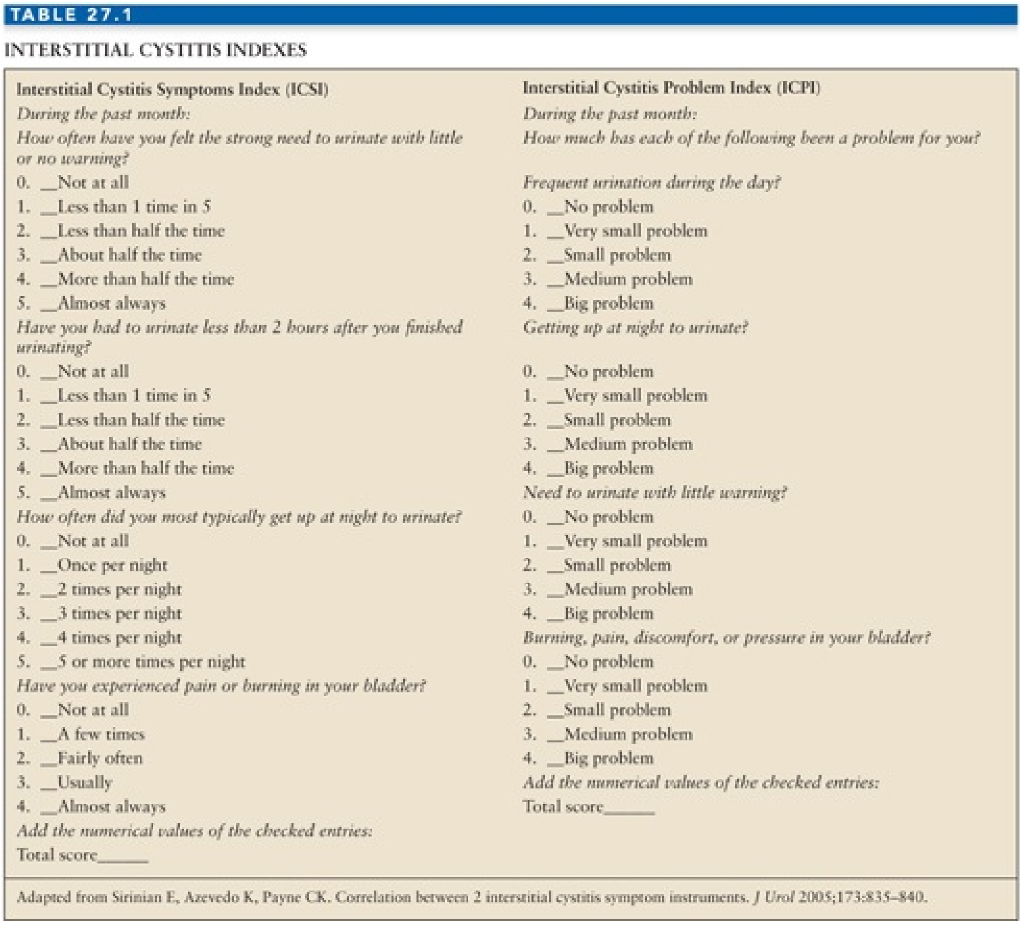

TABLE 27.1

INTERSTITIAL CYSTITIS INDEXES

Interstitial Cystitis Symptoms Index (ICSI)

During the past month:

How often have you felt the strong need to urinate with little or no warning?

0. _Not at all
1. _Less than 1 time in 5
2. _Less than half the time
3. _About half the time
4. _More than half the time
5. _Almost always

Have you had to urinate less than 2 hours after you finished urinating?

0. _Not at all
1. _Less than 1 time in 5
2. _Less than half the time
3. _About half the time
4. _More than half the time
5. _Almost always

How often did you most typically get up at night to urinate?

0. _Not at all
1. _Once per night
2. _2 times per night
3. _3 times per night
4. _4 times per night
5. _5 or more times per night

Have you experienced pain or burning in your bladder?

0. _Not at all
1. _A few times
2. _Fairly often
3. _Usually
4. _Almost always

Add the numerical values of the checked entries:

Total score_____

Interstitial Cystitis Problem Index (ICPI)

During the past month:

How much has each of the following been a problem for you?

Frequent urination during the day?

0. _No problem
1. _Very small problem
2. _Small problem
3. _Medium problem
4. _Big problem

Getting up at night to urinate?

0. _No problem
1. _Very small problem
2. _Small problem
3. _Medium problem
4. _Big problem

Need to urinate with little warning?

0. _No problem
1. _Very small problem
2. _Small problem
3. _Medium problem
4. _Big problem

Burning, pain, discomfort, or pressure in your bladder?

0. _No problem
1. _Very small problem
2. _Small problem
3. _Medium problem
4. _Big problem

Add the numerical values of the checked entries:

Total score_____

Adapted from Sirinian E, Azevedo K, Payne CK. Correlation between 2 interstitial cystitis symptom instruments. *J Urol* 2005;173:835–840.

A physical examination that includes a thorough pelvic and neurologic examination should be performed. The female pelvic examination should include evaluation for tenderness of the anterior vaginal wall and levator muscles, the ability to contract and relax the pelvic floor muscles, and the degree of pelvic relaxation. A high-tone pelvic floor can contribute to a large portion of patient symptomatology (9). Urethral fullness, tenderness, or expression of pus may suggest a urethral diverticulum requiring further workup. Vaginal pH and wet-mount microscopic exam is beneficial in ruling out vaginitis or infectious etiology. Careful attention should be paid to vulvar or vestibular sensitivity, herpetic vesicles, atrophic vaginal mucosa, and any other cutaneous findings. A rectal examination can rule out any rectal abnormalities or masses, and in men, not only should the prostate be palpated but the tenderness or spasm of the pelvic floor muscles should also be assessed because this is a common cause of pelvic pain and voiding dysfunction. A urinalysis and urine culture should be performed to exclude active infection. Sterile pyuria should prompt staining for acid-fast bacilli to rule out genitourinary tuberculosis. If microscopic or gross hematuria is present, an initial workup including computerized tomography (CT) urography and cystoscopy is required in order to evaluate for bladder cancer or stone disease.

In patients with primarily urinary urgency, frequency, or incontinence, a trial of anticholinergics may cause symptoms to subside supporting the diagnosis of OAB. If symptoms persist, if pelvic pain worsens with bladder filling, or if severe dysuria is present, a cystoscopic evaluation is warranted. IC was first described as a distinct ulcer seen on cystoscopic examination (1). This lesion is typically red, raised, and friable and can be seen during cystoscopy without hydrodistention. The lesion is difficult to distinguish from carcinoma in situ, and a biopsy with cauterization of the lesion is required to confirm its benign nature. Although less than 15% of patients diagnosed with IC/BPS have an ulcer in their bladder, symptom improvement with fulguration can be remarkable (10). Ulcerative patients are typically older and have more severe bladder-associated pain and a smaller anesthetic bladder capacity (11).

In patients in whom a diagnosis of IC/BPS is highly suspected clinically, cystoscopy with hydrodistention under anesthesia may reveal petechial hemorrhages and glomerulations, which are found in over 90% of women with the syndrome. However, the presence of petechial hemorrhages alone is not diagnostic, as they can also be seen in normal men and women (12). A computerized cystometrogram may also be performed to look for uninhibited contractions and to determine the functional bladder capacity. Some investigators have suggested the use of the potassium sensitivity test (PST) to diagnose IC/BPS (13). The PST is based on the hypothesis that there is increased epithelial permeability in the bladder of IC patients and potassium is very irritating to the exposed tissue. However, a significant false-positive rate exists, and many patients will eventually be diagnosed with a normal bladder (14). Additionally, 17% of women with IC/BPS may have a negative test (15). For these reasons, PST is not currently recommended during evaluation and diagnosis.

INDICATIONS FOR SURGERY

Any patient with significant tenderness of the pelvic floor muscles on exam should undergo transvaginal/transrectal myofascial release. This may be augmented with trigger point injections into these muscles. Patients with unexplained urinary urgency, frequency, and pelvic pain who are refractory to conservative therapies are candidates for an operative hydrodistention, which may be not only diagnostic but also therapeutic. Patients with ulcerative disease may benefit from ablation of the ulcers with cautery or laser (10,16). This procedure also evaluates the maximum anesthetic bladder capacity, which may predict symptom severity and treatment failures (17).

Radical surgery for IC/BPS is rarely indicated and should be used as a last resort. However, in carefully selected patients, this can be a viable and well-tolerated treatment. Magnetic resonance imaging (MRI) of the pelvis may demonstrate a thickened, end-stage bladder that may be amenable to radical surgery (Fig. 27.1). Maximum anesthetic bladder capacity is often <200 mL. Patients who undergo bladder augmentation or continent diversion need to be willing and able to perform clean intermittent catheterization. Additionally, patients must accept that frequency symptoms may improve but that pain may persist. Diverting the urine without removing the diseased bladder is not always sufficient to relieve the symptoms of IC/BPS. Therefore, any diversion procedure for pain should be accompanied by cystectomy (18). Finally, neuromodulation has been effective in treating refractory urinary urgency and frequency (19). It has also recently shown to be effective in IC/BPS patients, although not officially indicated for pelvic pain syndromes. Because IC/BPS is a syndrome of urgency, frequency, and pain, patients who are refractory to standard therapies would be candidates for nerve stimulation.

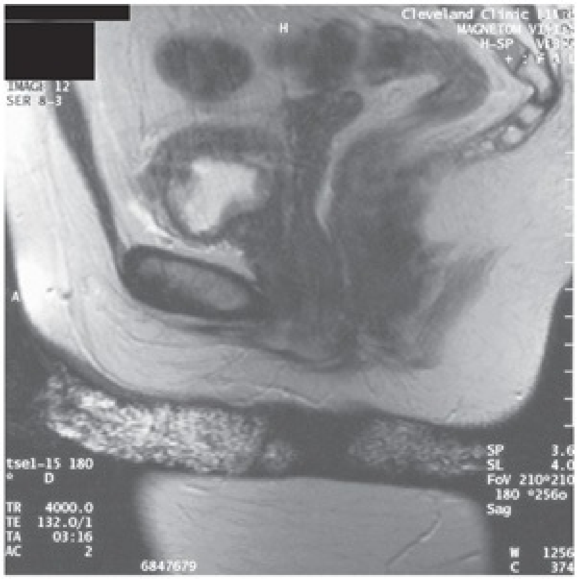
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FIGURE 27.1 MRI scan of pelvis of 28-year-old woman with end-stage interstitial cystitis demonstrating a small, thickened, contracted bladder. (Courtesy of Raymond Rackley, Cleveland Clinic Foundation.)

NONSURGICAL THERAPY

Establishing a diagnosis of IC/BPS in itself is usually therapeutic and alleviates patient frustrations. A multimodality approach along with patient education is the most effective means of treating IC/BPS. Behavioral therapies must be stressed, such as fluid management, pelvic floor physical therapy, dietary restrictions, and relaxation therapy (20). Many patients suffer from pelvic floor spasm, which causes pelvic pain, dyspareunia, and urinary hesitancy. Treatment by a therapist knowledgeable in myofascial release techniques may be of benefit (9,21). Once behavioral therapy and education are optimized, oral medication is a reasonable first-line treatment for IC/BPS.

At the present time, the only oral therapy approved by the U.S. Food and Drug Administration (FDA) for IC/BPS is pentosan polysulfate sodium (Elmiron, Janssen Pharmaceuticals, Inc), a glycosaminoglycan that binds tightly to the bladder mucosa. Pentosan polysulfate may be considered after behavioral and symptom management therapy for IC/BPS. Because it may require several months before any clinical improvement is seen, it should not be used as a single agent for the treatment of IC/BPS. Hydroxyzine has antihistaminic and antianxiety properties and affects mast-cell degranulation, which may play a role in symptoms of IC/BPS. Treatment is started at 10 mg orally daily and can be titrated up based on sedation side effects. However, neither pentosan polysulfate nor hydroxyzine showed high response rates in recent clinical trials (22). Muscle relaxants such as diazepam or low-dose baclofen may be useful in women with accompanying pelvic floor spasm, although study outcomes have been mixed (23,24).

Tricyclic antidepressants such as amitriptyline or imipramine may improve symptoms due to their anticholinergic and antipain effects (16). Recent meta-analysis showed that amitriptyline had a large treatment effect on pain, urgency, frequency, and ICSI scores (25). Finally, chronic pain is recognized as a legitimate complaint and should be treated aggressively. Various narcotics and anti-inflammatories can be tried, along with nerve blocks or implantable pain pumps, to treat the severe pain that can be associated with IC/BPS. The enlistment of a pain specialist may be helpful for specific blocks or for management of long-term narcotic contracts. With increasing scrutiny of opioid abuse and diversion, this treatment is becoming more complex. Urinary analgesics (phenazopyridine, methenamine, and other combination formulations) may also be effective as part of combination therapy. Cyclosporine has been used in some clinical trials, but when applied to the general population of IC/BPS patients, the results are inconclusive. For patients with the ulcerative form and symptom improvement after ulcer fulguration, treatment with a potent immunologic modifier such as cyclosporine has shown to be effective (26).

Intravesical therapies have been a mainstay in treatment for many years due to the prior belief that this was a disease limited to the bladder. Dimethyl sulfoxide (DMSO) is the only FDA-approved intravesical therapy for this disease. DMSO is a product derived from paper pulp and is mainly used as an industrial solvent. It is given in the office setting as a 50% solution in 50 mL of sterile saline. Patients rarely have side effects, although they may complain of transient urethral pain or irritation after the first instillation or a garliclike odor from their mouth. If effective, symptoms may resolve for months to even years (27).

Bacille Calmette-Guérin (BCG) is prepared from an attenuated strain of bovine tuberculosis bacillus, *Mycobacterium bovis*, and is given intravesically as a 50-mg dose in 50-mL saline solution. While traditionally used for treating carcinoma in situ of the bladder or low-stage urothelial carcinoma, it appeared to show promise as an intravesical agent in treating IC/BPS. In a randomized placebo-controlled clinical trial, 21% of patients responded to BCG, compared to 12% of placebo. However, the difference was not statistically significant ($P = .062$), and therefore, this should not be offered outside of the research setting.

Other second-line agents that have been used include capsaicin, heparin, sodium oxychlorosene, and silver nitrate. The most commonly described “cocktails” include heparin, lidocaine, and sodium bicarbonate. Side effects of these bladder instillations seem minor, and some patients gain significant improvements in symptoms. They are generally listed as second-line treatments, although their duration of effects is limited and require repeat and scheduled instillations (28,29).

Because many patients present with high-tone pelvic floor and myofascial tenderness, transvaginal trigger point injections can also be offered. On exam, the levator muscles are palpated, and areas of discreet tenderness and bands can be felt. Injections usually consist of a local anesthetic, although techniques of dry needling and Botox have also been described. The underlying mechanism is thought to include disruption of the positive-feedback cycle of pain/spasm as well as local release of inflammatory and vasodilatory mediators. Our technique involves a mixture of ropivacaine 0.5% and triamcinolone (40 mg) injected transvaginally using a curved stylet (Fig. 27.2). Others may prefer the straight Iowa Trumpet; however, the long spinal needles employed easily curve in the stylet and enter the muscles perpendicularly. A 7-inch 22-gauge spinal needle is used to infiltrate the muscles, aspirating first to avoid intravascular injections. Each trigger point is injected with 2 to 5 mL, although multiple injections along the levator group on the side of spasms are also effective. A tampon is placed for 5 minutes after the injections to tamponade any mucosal bleeding. The response to injections should be immediate and can be quantified with a VAS (0 to 10) pre- and postprocedure. Some patients experience a brief flair of symptoms after the anesthetic wears off and before the anti-inflammatory response from local steroid injections occurs. Complications from trigger point injections include vaginal bleeding, leg weakness, perineal numbness, vaginal hematoma, stress urinary incontinence, and systemic reactions to local anesthetic. These are usually minor events and of short duration. The clinician must also be aware of the maximum dose for whichever anesthetic chosen to avoid systemic effects. Injections can be repeated every 4 to 6 weeks in an attempt to break the pain/spasm cycle.

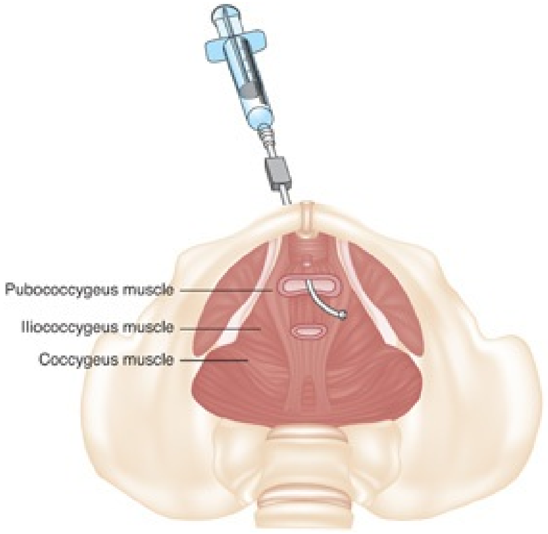

FIGURE 27.2 Technique of transvaginal trigger point injection. A curved cannula is used to advance a 7-inch spinal needle into the levator muscles.

SURGICAL TECHNIQUE

Bladder Hydrodistention

A complete cystoscopy is performed to assess the urethra and bladder for any masses, stones, or diverticula (Fig. 27.3). After careful inspection, the bladder is filled by gravity drainage under anesthesia at 100 cm H_2O pressure to its capacity. Upward pressure with a finger along each side of the urethra is often needed to maximally distend the bladder to prevent leakage around the cystoscope. The bladder is distended until no further water will run into the bladder, and this is allowed to dwell for 2 minutes. The bladder is drained and the volume measured. The procedure is then repeated a second time.

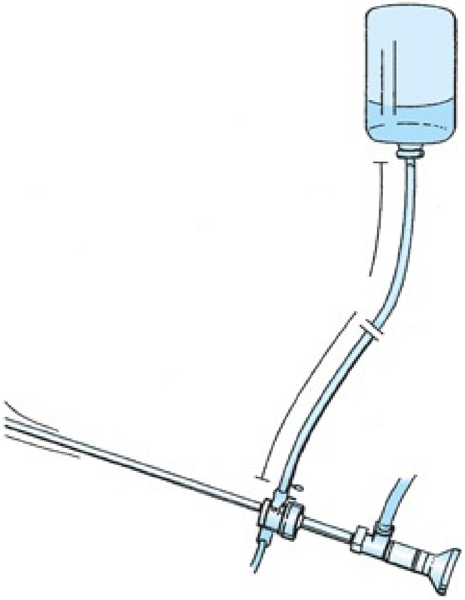

FIGURE 27.3 Hydrodistention is carried out with the irrigation bag hung 100 cm above the level of the bladder. Bladder capacity is reached when irrigant flow stops. During filling, the bladder mucosa is typically normal-appearing. After 2 minutes of distention, the bladder is drained and the capacity is measured. At the termination of bladder emptying, the irrigant fluid is often blood-tinged or grossly hemorrhagic in patients with interstitial cystitis (IC). Repeat cystoscopy will demonstrate diffuse glomerulations in all sectors of the bladder consistent with IC. Repeat hydrodistention is performed to maximally distend the bladder.

A normal bladder will accommodate up to (or over) 1 L under a general anesthetic. On the other hand, the bladder of a patient with the ulcerative form of IC/BPS will be less compliant, often stretching to <350 mL. Typically with IC/BPS, there is terminal hematuria noted when the bladder is drained. Upon reinspecting the bladder, the vast majority of patients will have glomerulations seen in all sectors of the bladder, suggestive of IC. Patients having the ulcerative form will have distinct inflammatory lesions on cystoscopy called Hunner lesions, and with hydrodistention, deep cracks in their bladder at the site of ulcers may occur (1) (Fig. 27.4).

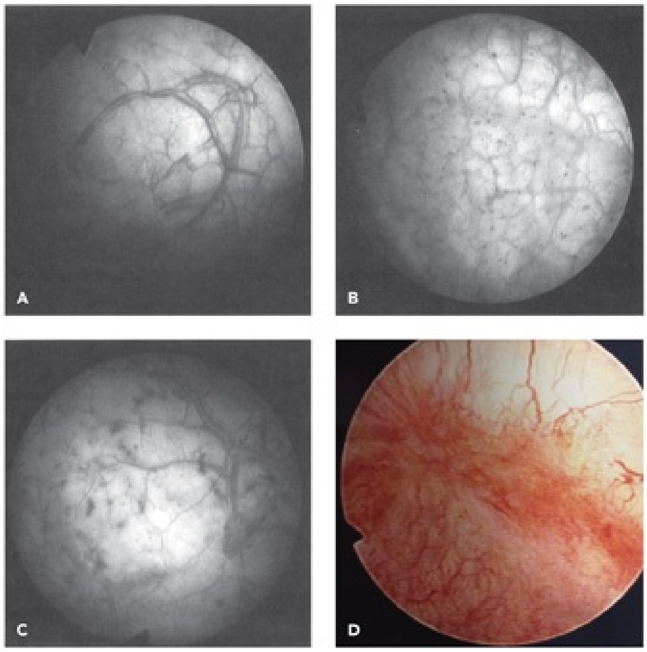

FIGURE 27.4 **A:** Normal appearance of the bladder urothelium before hydrodistention in a patient with symptoms consistent with interstitial cystitis. **B:** Same patient following hydrodistention. The urothelium is abnormal, revealing minimal to moderate glomerulation. **C:** Cystoscopic appearance of a patient with moderate glomerulations and submucosal hemorrhage. **D:** Hunner lesions with marked hemorrhage surrounding the ulcer. This patient was successfully treated with neodymium:YAG laser ablation therapy.

Endoscopic Resection or Fulguration of Ulcers

Approximately 15% of IC/BPS patients comprise the ulcerative subset, and they generally have worse pain and frequency symptoms. A resectoscope with loop electrocautery can be used to resect these lesions and cauterize the base (30). Alternatively, the involved areas can be cauterized with a Bugbee electrode, ball electrode, or neodymium:YAG laser. The laser is set at 15 W with a firing duration of 1 to 3 seconds. The laser fiber is maintained in constant motion over the target, and the procedure is completed when the ulcer is completely blanched (16). At the first treatment session, it is imperative to biopsy the lesions to avoid confusion with more devastating carcinoma in situ. Further biopsy is unnecessary because there is no established pathway from ulcerative IC to bladder carcinoma.

Augmentation Cystoplasty

Simple augmentation of the bladder should only be performed if one has an operative bladder capacity with hydrodistention of <300 mL and symptoms of severe urgency/frequency. The bladder is isolated transabdominally, and a posterior-based U-shaped incision is created on the anterior bladder (Fig. 27.5). A 30-cm segment of distal ileum is isolated in the standard fashion and opened along its antimesenteric border. The ileal segment is folded to create a nonperistaltic ileal patch. This is secured to the anterior bladder with running absorbable suture, effectively increasing the functional capacity of the bladder. Care must be taken to open the bladder widely to avoid creating a poorly draining diverticulum. Patients with known inflammatory bowel disease or prior ileocecectomy are not candidates for this approach. Recent advances in pediatric reconstruction and robotic-assisted technology have shown that ileocystoplasty can also be approached using minimally invasive techniques (31,32). More in-depth discussion is available elsewhere in this text. Patients undergoing an augmentation must understand that their pelvic pain symptoms may not resolve from augmentation alone. Additionally, because the detrusor is incised, the emptying mechanism of the bladder is altered, and patients may need to perform intermittent straight catheterization to effectively empty their bladder. Mucous production, stone formation, and bladder rupture are known complications from the addition of bowel to the bladder wall, and patients should be followed accordingly.

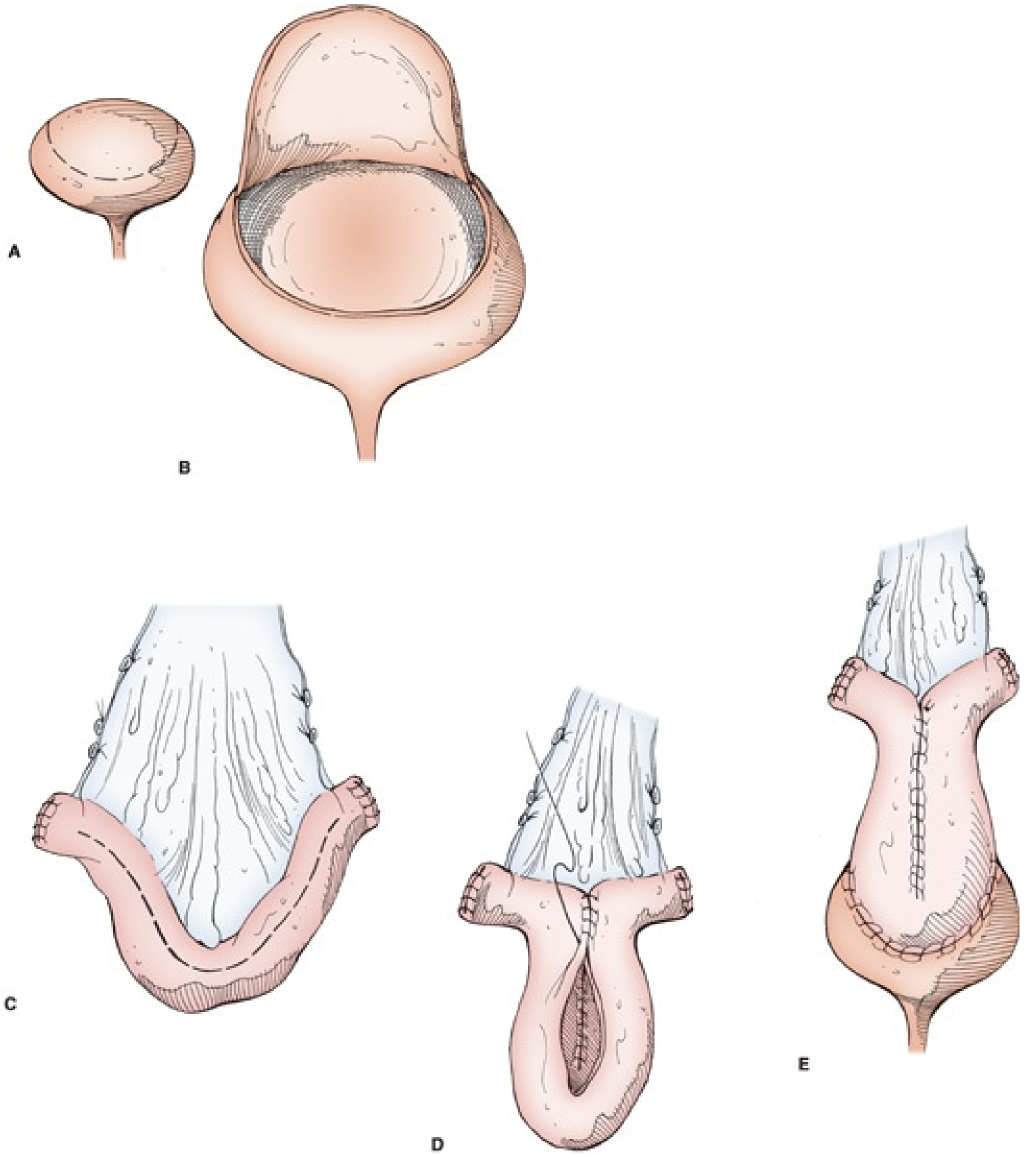

FIGURE 27.5 Ileal augmentation cystoplasty. **A:** A posterior-based U-shaped incision is created on the anterior bladder. **B:** Completion of the posterior-based bladder flap. **C:** A 30-cm segment of the distal ileum is isolated and divided along the antimesenteric border. **D:** The ileal segment is then folded and the posterior surface is closed completely with a running absorbable suture. The anterior segment is partially closed. **E:** Completed ileal bladder anastomosis.

Partial Cystectomy and Substitution Cystoplasty

Supratrigonal cystectomy with enterocystoplasty is preferred over simple augmentation cystoplasty because most of the diseased bladder is removed (33) (Fig. 27.6). This technique should be reserved for patients with small bladder capacity found on hydrodistention under an anesthetic (<300 mL). Patients with a primary pain complaint are not good candidates for supratrigonal cystectomy, particularly if the pain is urethral in nature. In addition, patients should be able to perform intermittent straight catheterization and bladder irrigation in case of poor emptying or mucus formation.

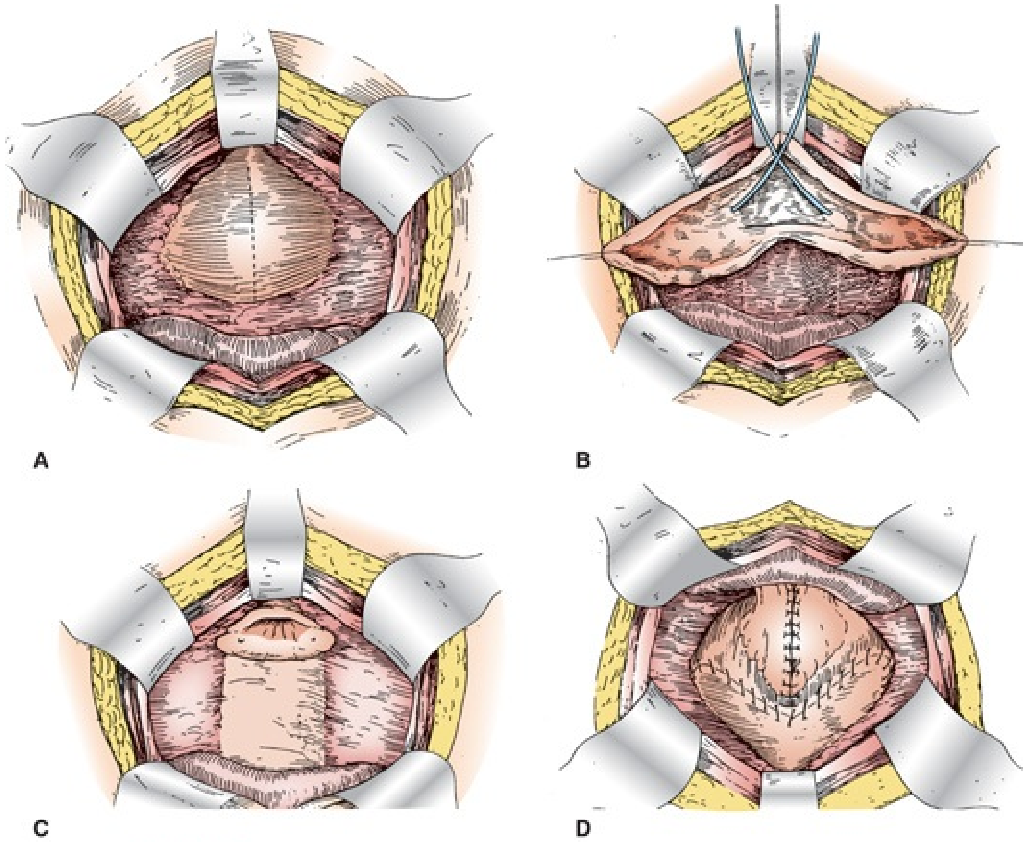

FIGURE 27.6 Technique of subtotal cystectomy and substitution cystoplasty. A: The bladder is being bivalved with electrocautery. B: View of the bladder with both ureteral orifices cannulated with ureteral catheters to avoid injury to ureters during bladder resection. C: Completion of subtotal cystectomy with only a small cuff of bladder remaining, which consists of the urethra, bladder neck, and trigone. D: Completed anastomosis of the bowel onto the bladder cuff. A Foley catheter (not shown) and a suprapubic tube are placed to ensure adequate drainage during the immediate postoperative period.

The patient is placed in a supine position and a Foley catheter is placed sterilely in the bladder. The peritoneal cavity is entered through a vertical midline incision, and an appropriate segment of either large or small bowel with a mesentery long enough to reach down to the bladder is selected. The preferred bowel segments are the cecum, sigmoid colon, or ileum. The bladder is filled via the Foley catheter and divided using a clamshell technique, exposing the trigone. Ureteral catheters are placed before resection of the bladder to avoid injury to the ureters. Using electrocautery, a supratrigonal cystectomy is performed, resecting all but a 1- to 2-cm cuff of bladder that includes the trigone and bladder neck. Placing Allis clamps on the edges of the remaining bladder controls hemostasis. The vesicoenteric anastomosis is completed using a single-layer running closure of 3-0 absorbable polyglactin or polydioxanone suture. A 22Fr Foley catheter is placed through the bowel segment and used as a suprapubic tube. Both tubes are kept to dependent drainage for 21 days, when a cystogram is performed to ensure the integrity of the anastomosis. Many women are able to empty with a Credé maneuver, but a regimen of intermittent catheterization is imperative to evacuate mucus and assure complete emptying.

Total Cystectomy with Orthotopic Neobladder or Urinary Diversion

A total cystectomy has the benefit of removing the entire diseased bladder and may be the treatment of choice for the patient with an “end-stage” bladder. The choice of performing a continent versus incontinent diversion is based mainly on patient preference. If a patient has significant urethral symptoms, an orthotopic neobladder may not be the preferred conduit. The benefits of continent diversions are obvious; however, there have been conflicting reports of IC/BPS developing in the continent bowel segments (34–36). An informed and motivated patient would be the best candidate for a continent diversion. The techniques of cystectomy and urinary diversion, including complications, are described elsewhere.

Sacral Nerve Stimulation

Chronic inflammation in a pelvic organ may lead to nerve upregulation to the spinal cord, affecting all pelvic structures. Sacral nerve modulation (InterStim, Medtronic, Inc, Minneapolis, MN) is approved by the FDA for urinary urgency, frequency, urge incontinence, idiopathic urinary retention, and fecal incontinence. Preoperatively, the efficacy of sacral nerve stimulation is determined by a test performed prior to placing a permanent generator. If a patient experiences at least a 50% improvement in the symptoms and desires a permanent implant, an implantable generator can be placed permanently in a subcutaneous pocket in the upper buttocks. Patients have an external programmer to control the degree and frequency of stimulation and multiple programs can be stored on one device. The complete procedure and description of technique is described elsewhere in this edition.

Currently, a smaller generator is available that may be easier to implant and more comfortable for patients. Battery life on this smaller device is 4 years, compared to 8 years for the larger generator. Regardless, patients must be aware that they will require replacement of their generator later in life. Long-term complications have been minimal with the device. Most commonly revision or explants are for device failure, battery replacement, or loss of efficacy. Reported rates vary, with revisions ranging from 16% to 20% and explantation 10% to 24% (37,38). Future limitations need also be discussed with the patient, including chest or body MRI, future pregnancy, and underwater diving activities.

Pudendal Neuromodulation

Stimulation of the pudendal nerve is not FDA-approved but may offer an alternative to sacral nerve stimulation. Multiple studies have shown inhibition of the micturition reflex with afferent pudendal stimulation, which also results in an increase in bladder capacity and a decrease in uninhibited bladder contractions (39,40). Because afferent signaling is thought to be the primary driver of neuromodulation, using the pudendal nerve spreads the signal more broadly across the sacral nerve roots leading to an enhanced signal being delivered to the central nervous system. Studies have shown promise in using the pudendal nerve as a site of stimulation in patients with urinary urgency, frequency, and pelvic pain (41,42).

Similar to sacral lead placement, the patient is placed prone with the buttocks and posterior thighs prepped and draped. Electromyography (EMG) monitoring must be used to confirm nerve stimulation because the bellows response can be confused with cross-stimulation of motor branches of the proximal sacral nerve roots adjacent to the pudendal nerve. Electrodes are placed at 3 and 9 o'clock in the external anal sphincter and the ischial tuberosity palpated and marked. The skin 1 cm medial at the level of the anus is marked and infiltrated with local anesthetic. The 5-inch foramen needle is advanced medial to lateral toward to ischial spine while stimulating at 5 V per 5 Hz (Fig. 27.7). Fluoroscopy is used to confirm the correct trajectory and continuous EMG monitoring assesses for compound muscle action potentials (C map) at the anal sphincter. Leg rotation or other gluteal nerve stimulation should be assessed and avoided because this will limit the patient's ability to activate and use the device. After a small skin incision is made, the directional guide wire is placed and the blunt-tip lead introducer is advanced again while being stimulated. Once C map is confirmed, the longer 41-cm quadripolar lead is placed and tested for response. We find that optimal placement results in nerve stimulation between 1 and 2.5 V on at least three of the four leads. Withdrawal of the lead introducer will deploy the tines and secure the lead in place. A small subcutaneous pocket is created just below the ipsilateral iliac crest for a future pulse generator similar to the sacral technique. The tunneling device is then used to bring the lead to this pocket, and connections are made to the cutaneous extension wire. This wire is then tunneled to the contralateral side for a 2-week stage I trial period (Fig. 27.8).

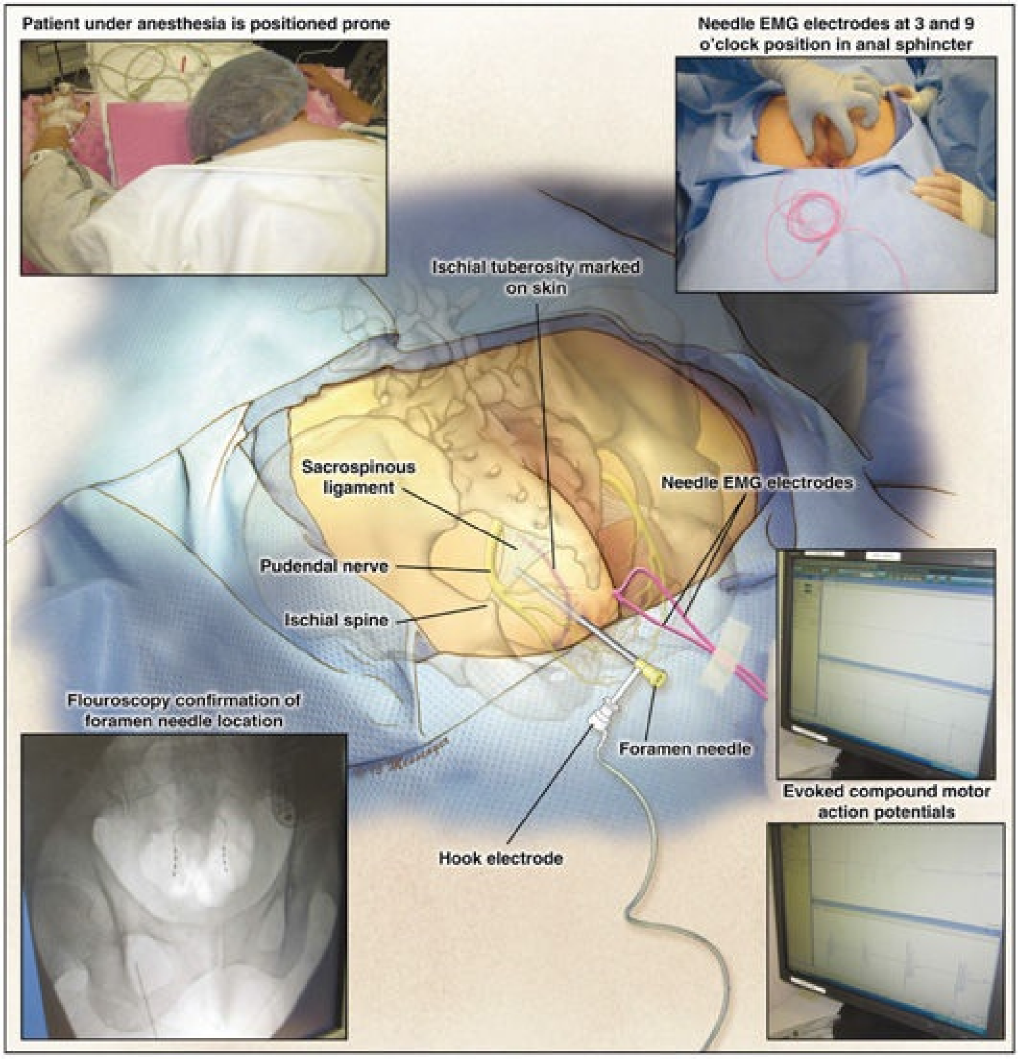
Patient under anesthesia is positioned prone
Needle EMG electrodes at 3 and 9 o'clock position in anal sphincter
Ischial tuberosity marked on skin
Sacrospinous ligament
Needle EMG electrodes
Pudendal nerve
Ischial spine
Flouroscopy confirmation of foramen needle location
Foramen needle
Evoked compound motor action potentials
Hook electrode

FIGURE 27.7 Placement of the pudendal tined lead just medial to the ischial tuberosity through the ischiorectal space. *EMG*, electromyography. (Reprinted with permission from Peters KM. Pudendal neuromodulation for sexual dysfunction. *J Sex Med* 2013;10:908–911. Copyright © 2013 International Society for Sexual Medicine.)

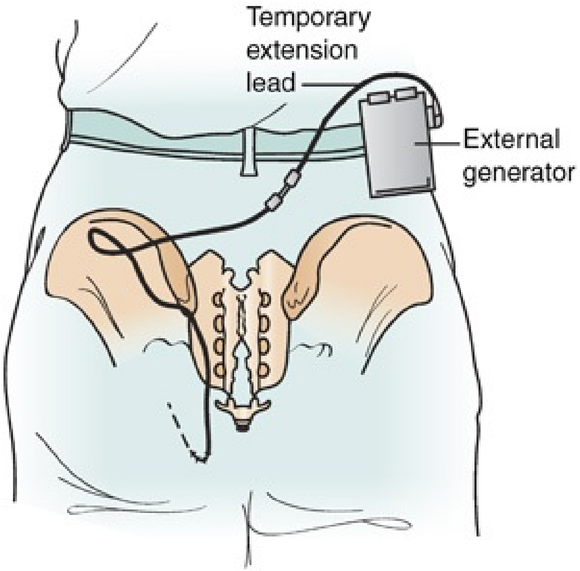

FIGURE 27.8 Stage I implant. The lead is tunneled to a small, subcutaneous pocket on the ipsilateral side. The lead is then connected to a temporary extension lead, which is tunneled to the contralateral side and externalized. The external generator is then connected to the extension lead. The patient is discharged to home, and sacral nerve stimulation is tested over a 14- to 21-day period. Voiding logs and pain scores are maintained, and the program is changed as needed to maximize the clinical response.

In a recent single-blind crossover trial, 22 patients had both sacral and pudendal tined leads placed. Each was stimulated in random order. In responders (>50% improvement in their symptoms), the “better” lead was chosen by the patient (Fig. 27.9). Pudendal lead placement took a mean of 19.6 minutes compared to 27.4 minutes for sacral leads ($P = .039$). Seventy-seven percent had a permanent generator placed after the trial period. The mean ICSI score decreased from 14.3 preoperatively to 10.7 at 6 months postoperatively in the sacral nerve stimulation group ($P = .03$) and decreased from 15.7 to 8.6 in the pudendal group ($P = .009$). The decrease in the ICPI was statistically significant only for the pudendal group, with a decrease from 12.9 to 7.5 at 6 months ($P = .002$). Average preoperative frequency was 24.07 per 24 hours for both groups. At 6 months, the mean total 24-hour voids decreased to 13.94 in the sacral group ($P = .001$) and to 12.84 in the pudendal group ($P = .001$). Mean voided volume increased from the preoperative value of 81.8 mL to 152.8 mL in the sacral group ($P = .001$) and to 158.0 mL in the pudendal group ($P = .001$). Of patients having a permanent generator placed, the majority (77%) chose to have the pudendal lead permanently implanted. A follow-up of 55 pudendal lead patients showed significant improvement in urgency, frequency, and pelvic and bladder pain. Nevertheless, further studies with larger numbers are needed to determine if pudendal nerve stimulation is as effective as or better at reducing urgency, frequency, and pain symptoms than sacral stimulation.

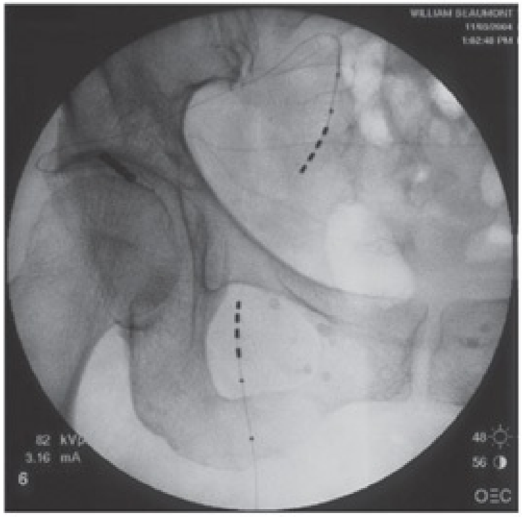

FIGURE 27.9 Postoperative photograph showing both sacral and pudendal leads in place. The pudendal lead was chosen by the majority of patients in a randomized, single-blind crossover study.

Posterior Tibial Nerve Stimulation

The tibial nerve arises from L4 through S3 and is a branch of the sciatic nerve. As with sacral and pudendal stimulation, it is possible to stimulate the posterior tibial nerve and modulate the innervation to the bladder, urinary sphincter, and pelvic floor (43,44) (Fig. 27.10). The technique stimulates the posterior tibial nerve with a 34-gauge needle placed bilaterally at SP-6. The needles are placed approximately 4 cm deep at a 30-degree angle cephalad. An adhesive grounding electrode is applied on each side near the medial calcaneus. Stimulation of the posterior tibial nerve is done with amplitude of 0.5 to 10.0 mA using a fixed pulse width (200 μs) and frequency (20 Hz). Stimulation is applied for 30 minutes. The stimulation needs to be done on a weekly basis for 12 weeks, after which an attempt to wean treatments to once a month is tried. Efficacy for posterior tibial nerve stimulation (PTNS) has been shown in a randomized sham-controlled trial for OAB symptoms (45) and is comparable to pharmacotherapy (46). No trials have directly compared PTNS response for patients with primary IC/BPS on pain symptoms. The limitation of this therapy is the repeated treatments and office visits over time.

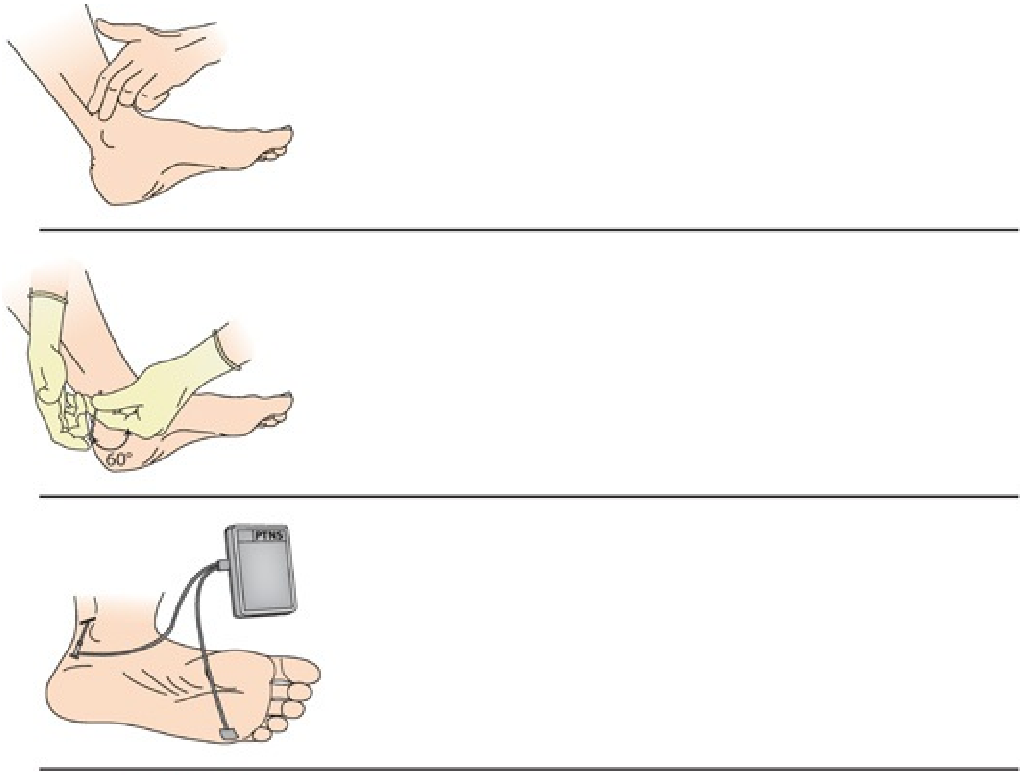

FIGURE 27.10 Neuromodulation of the posterior tibial nerve. A 34-gauge acupuncturelike needle is inserted approximately 3 to 4 cm deep to the tibial nerve for stimulation.

Denervation

Bladder denervation procedures have been reported in the treatment of patients with intractable bladder pain and urinary frequency and urgency. Division of the posterior sacral roots, posterior rhizotomy, or division of the inferior vesical neurovascular pedicle may result in temporary improvement in urinary frequency, urgency, and pain. Ingelman-Sundberg (47) described a more selective denervation in which a transvaginal approach is used to resect the inferior hypogastric plexus, dividing both the sympathetic and parasympathetic fibers. Candidates for the transvaginal denervation are selected by first performing a subtrigonal injection of bupivacaine, which, if successful, results in significant relief of their irritative symptoms. However, with the advent of more oral therapies, along with neuromodulation, denervation is mainly mentioned in this section for its historical significance.

More recently, the introduction of intradetrusor injections of botulinum toxin for neurogenic and nonneurogenic OAB has translated into studies for patients with IC/BPS. Well-designed studies have led to the approval of onabotulinumtoxinA (Botox, Allergan Inc, Irvine, CA) for OAB. Using 100 U of toxin, investigators showed improvement in maximum bladder capacity, ICSI, ICPI, and pain VAS scores, alone and combined with hydrodistention (48,49). Treatments require repeat injections every 3 to 12 months and expose the patients to the risks of urinary retention and urinary tract infections. These small studies support this use of botulinum toxin, although results have generally been limited to small, nonrandomized samples. Response rates were also poor in those with ulcerative forms of IC/BPS (50).

OUTCOMES

Complications

Complications of hydrodistention with or without fulguration are listed in Table 27.2. The most serious complication is bladder rupture, which should be considered if there is resumption of fluid inflow after maximally distending the bladder, return of significantly less fluid than what was instilled upon bladder drainage, or severe suprapubic or abdominal pain or distention. If a bladder rupture is suspected, an immediate cystogram should be performed. If the rupture is extraperitoneal, prolonged Foley catheter drainage is usually all that is needed to allow the rupture to heal spontaneously. If intraperitoneal leakage of contrast is seen, however, immediate exploration and repair are warranted to prevent peritonitis from urine leakage in the peritoneal cavity.

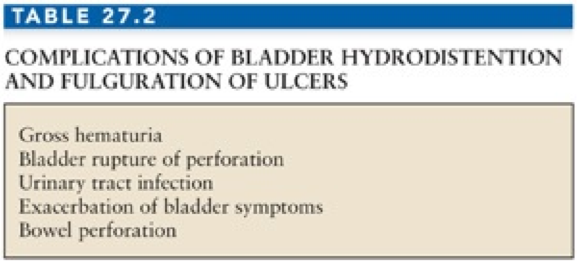

TABLE 27.2

COMPLICATIONS OF BLADDER HYDRODISTENTION AND FULGURATION OF ULCERS

Gross hematuria
Bladder rupture of perforation
Urinary tract infection
Exacerbation of bladder symptoms
Bowel perforation

Early and late complications secondary to major bladder reconstruction are listed in Table 27.3. Persistence of IC/BPS symptoms is probably the most common and disheartening outcome for both the patient and surgeon.

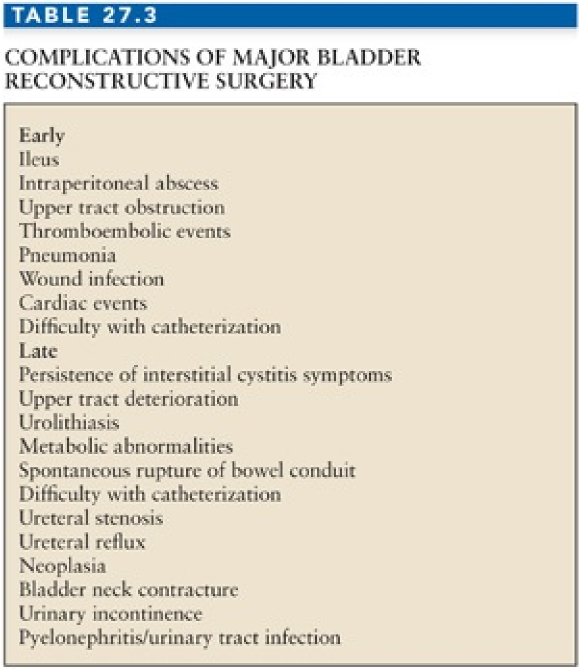

TABLE 27.3

COMPLICATIONS OF MAJOR BLADDER RECONSTRUCTIVE SURGERY

Early
Ileus
Intraperitoneal abscess
Upper tract obstruction
Thromboembolic events
Pneumonia
Wound infection
Cardiac events
Difficulty with catheterization
Late
Persistence of interstitial cystitis symptoms
Upper tract deterioration
Urolithiasis
Metabolic abnormalities
Spontaneous rupture of bowel conduit
Difficulty with catheterization
Ureteral stenosis
Ureteral reflux
Neoplasia
Bladder neck contracture
Urinary incontinence
Pyelonephritis/urinary tract infection

The major risk of selective denervation cystolysis is ureteral injury during the vaginal dissection and is avoidable by placing ureteral catheters.

No serious, irreversible, adverse events have been reported with sacral nerve stimulation. Complications associated with InterStim are listed in Table 27.4. Reoperation occurs in approximately 25% of patients undergoing sacral nerve implantation. Causes for reoperation include sensory discomfort, lead migration, device failure, pocket revision, and infection. Infection of the device requiring explantation occurs infrequently, in 5% of patients in a recent review of a large series (37). Others have described perioperative cephalosporin use as a risk factor for infection, specifically for methicillin-resistant *Staphylococcus aureus* (51). Perioperative, broad-spectrum antibiotic coverage during implantation of the lead and generator should be administered to decrease the rate of infection.

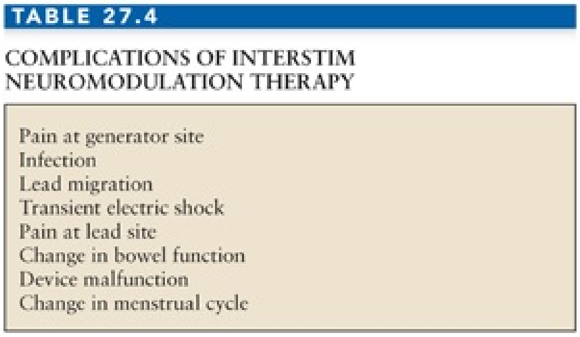

TABLE 27.4

COMPLICATIONS OF INTERSTIM NEUROMODULATION THERAPY

Pain at generator site
Infection
Lead migration
Transient electric shock
Pain at lead site
Change in bowel function
Device malfunction
Change in menstrual cycle

Results

Symptoms of IC/BPS may worsen for 2 to 3 weeks after a hydrodistention. Approximately 40% to 50% of IC/BPS patients undergoing a hydrodistention will have prolonged symptom improvement. If symptoms improve significantly for at least 4 to 6 months, repeat bladder hydrodistention may be indicated. Fulguration of Hunner lesions improves symptoms in over 80% of patients undergoing this therapy. The improvement in pain is usually seen in the first 2 to 3 days and may be long-lasting (16). For those who relapse, repeat fulguration of ulcers usually yields a similar response, 57% undergoing repeat procedure at 48 months (10).

The more aggressive, open surgical approaches have shown good results in carefully selected patients. Relief of symptoms in patients undergoing reconstructive surgery ranges between 60% and 90%. Long-term follow-up studies have shown durable responses in these highly selected patients. In one study, 41 patients underwent cystectomy, augmentation, or diversion only. Thirteen patients with intact or augmented bladder ultimately underwent cystectomy. Seventy-four percent reported pain-free status, and 68% were satisfied with the end result (52). Patients with ulcerative disease have been reported to have better results (53), although they have required completion cystectomy or ulcer fulguration at the trigonal remnant. Although a significant percentage of this highly select group of patients who undergo cystectomy will experience significant relief, there are reports of patients having persistent pelvic pain despite having no pelvic organs. This belies the importance of patient selection and expectations preoperatively.

We reviewed our experience with sacral nerve modulation for refractory IC/BPS (54). When a traditional test was performed with a temporary lead, we had a test-to-implant rate of 52% versus a 94% test-to-implant rate in the staged approach. The benefit of the staged test is that the permanent lead is more programmable and can be tested for an extended period of time. If a response is found, the lead does not need to be removed prior to placing the generator, and the settings that worked on the temporary generator can be programmed into the permanent implanted neurostimulator so that there is no interruption in therapy. Twenty-six patients with refractory IC/BPS who had failed six previous treatments for their disease were implanted with a permanent generator. With a mean follow-up of 5.6 months, 96% of patients said they would undergo the implant again and would recommend the therapy to a friend. Significant improvements were seen in the number of day voids (47%) and nocturia (60%). The majority of patients reported at least a 50% improvement in frequency (72%), urgency (68%), pelvic pain (71%), pelvic pressure (67%), quality of life (76%), incontinence (69%), and vaginal pain (60%). No patients showed a >50% worsening in any symptom. The overall reoperation rate was 11.5% (3 of 26). An objective measurement of pain improvement was reported. Twenty IC/BPS patients with pelvic pain had a permanent implant placed with a median follow-up of 272 days. Seventeen of 20 (85%) used chronic narcotics prior to implant. Nineteen of 20 (95%) reported moderate or marked improvement in pain after implantation of a permanent generator. Morphine dose equivalents (MDEs) decreased from 86 mg per day to 56 mg per day (34%) ($P = .015$)

after implant, and 24% stopped all narcotics.

A prospective study in patients with symptoms of IC/BPS refractory to more conservative treatments was performed after having InterStim implanted. At 14 months follow-up, mean voided volume increased from 111 mL to 264 mL, mean daytime frequency decreased from 17.1 to 8.7, and mean nighttime voids decreased from 4.5 to 1.1. Additionally, pain and symptom scores, measured using the Interstitial Cystitis Symptom and Problem Indices, all improved. Overall, 16 of 17 patients who underwent permanent implantation (94%) had improvement in all parameters at their most recent postoperative visit (55). Another literature review found the response rates for pain ranged from 51% to 77% in those with chronic pelvic pain (56).

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CHAPTER 28 MINIMALLY INVASIVE BLADDER PROCEDURES: RADICAL CYSTECTOMY, PARTIAL CYSTECTOMY, URACHAL EXCISION, DIVERTICULECTOMY

ANDRE LUIS DE CASTRO ABREU, SAMEER CHOPRA, AND INDERBIR S. GILL

It is estimated that 72,570 new cases of bladder cancer (BCa) with 15,210 deaths due to this disease occurred in the United States during 2013. Excluding dermatologic malignancies, BCa is the fourth most common cancer and eighth most common cause of death in American men (1). Radical cystectomy (RC) remains the gold standard for treatment of muscle-invasive or refractory non–muscle-invasive BCa (2). It provides satisfactory long-term oncologic outcomes, as it is curative for most patients who have localized disease, with 5- and 10-year recurrence-free survival rates approaching 70% (3). Minimally invasive RC has emerged as an alternative to open radical cystectomy (ORC). It successfully duplicates all technical aspects of the open approach and achieves similar functional and oncologic outcomes while minimizing blood loss, transfusion rates, and potentially, procedural morbidity.

The first laparoscopic radical cystectomy (LRC) with extracorporeal ileal conduit was reported in 1995 (4). Gill et al. (5,6) reported the first cases of LRC with ileal conduit and orthotopic ileal neobladder performed completely intracorporeally in 2000 and 2002, respectively. The first robot-assisted radical cystectomy (RARC) was performed in Germany in 2002, and in 2003, Menon et al. published the first case series of RARC (7,8). Like other robot-assisted surgeries, RARC is gaining popularity. In fact, the proportion of RARCs has consistently increased from 0.6% in 2004 to 12.8% in 2010, and more than 2,101 RCs were performed with robotic assistance to date (9,10). We perform RARC and urinary diversion routinely at our institution and herein present our step-by-step technique.

DIAGNOSIS

The diagnosis and staging of muscle-invasive BCa are addressed elsewhere in this book.

INDICATIONS

The indications for RARC are similar to ORC; therefore, patients with refractory high-risk non–muscle-invasive or muscle-invasive BCa are candidates for RARC. Our current contraindications include fixation of the bladder to surrounding structures and pelvic wall on bimanual palpation, bulky lymphadenopathy, and uncorrected bleeding diathesis. At this writing, the following conditions are no longer contraindications for RARC at our institution: bulky organ-confined primary tumors, history of pelvic surgery or radiation, history of neoadjuvant chemotherapy, morbid obesity, advanced age, aortoiliac vascular surgery, or endovascular stenting; these situations make the procedure challenging yet still feasible (11–13). In fact, RARC has been performed in locally advanced BCa (pT4) and in octogenarians with multiple comorbidities with acceptable outcomes (14,15).

ALTERNATIVE THERAPY

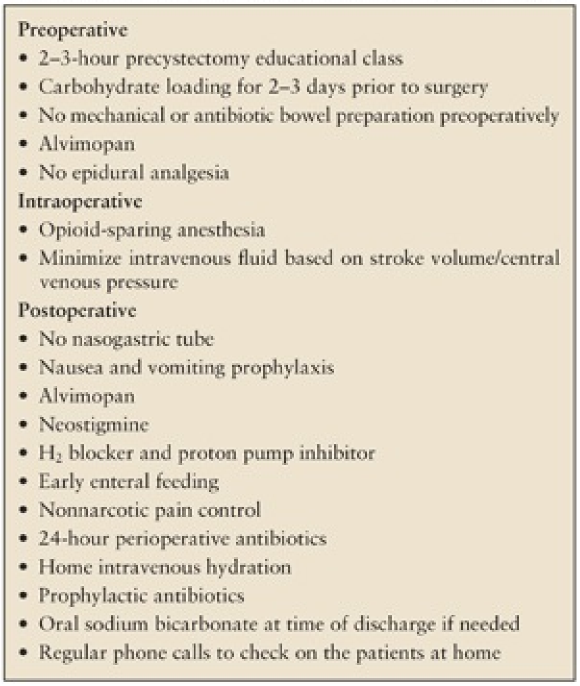
Bladder-preserving protocols using external beam and chemotherapy are available for those who may not be considered for radical cystectomy.

ENHANCED RECOVERY AFTER SURGERY PROTOCOL

Table 28.1 emphasizes part of our Enhanced Recovery after Surgery (ERAS) protocol.

TABLE 28.1

ENHANCED RECOVERY AFTER SURGERY PROTOCOL



Preoperative
- 2–3-hour precystectomy educational class
- Carbohydrate loading for 2–3 days prior to surgery
- No mechanical or antibiotic bowel preparation preoperatively
- Alvimopan
- No epidural analgesia

Intraoperative
- Opioid-sparing anesthesia
- Minimize intravenous fluid based on stroke volume/central venous pressure

Postoperative
- No nasogastric tube
- Nausea and vomiting prophylaxis
- Alvimopan
- Neostigmine
- H_2 blocker and proton pump inhibitor
- Early enteral feeding
- Nonnarcotic pain control
- 24-hour perioperative antibiotics
- Home intravenous hydration
- Prophylactic antibiotics
- Oral sodium bicarbonate at time of discharge if needed
- Regular phone calls to check on the patients at home

RADICAL CYSTECTOMY

Thorough preoperative evaluation is necessary, including cardiac and medical clearance. The patient starts with a clear liquid diet the day prior to surgery. A stoma site is marked before RARC for all patients by an enterostomal therapist. Heparin is administered 1 hour prior to surgery and intravenous antibiotic (typically cefoxitin) is administered at induction until 24 hours postoperatively. As such, the patient preparation is similar as for ORC.

Patient Positioning and Port Placement

Under general anesthesia, the patient is placed in supine position with abducted legs in the appropriate securely fashioned leggings (Fig. 28.1A). All pressure points are meticulously padded and the patient is secured to the surgical table. Sequential compression stockings are applied prior to induction. The patient is prepared from the nipples down to the midthighs, including the genitalia. A warming blanket covers the upper chest and shoulders. After sterile preparation and draping of the patient, a 20Fr Foley urethral catheter is inserted.

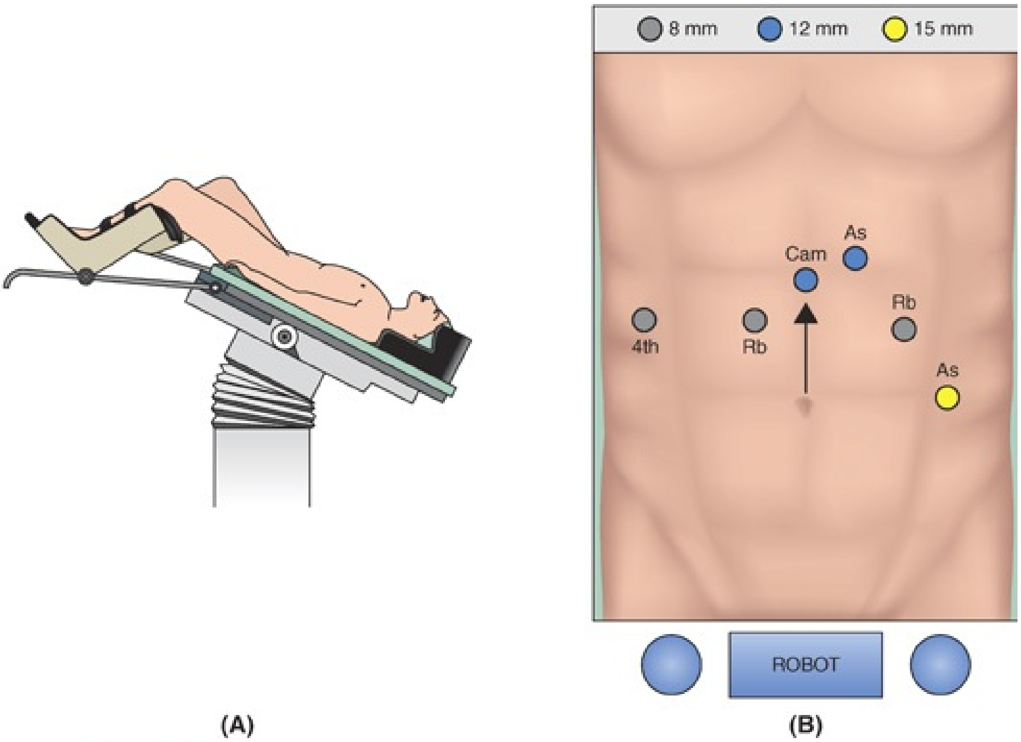


FIGURE 28.1 **A:** Patient is placed in supine position with abducted legs in steep Trendelenburg. **B:** Port placement for RARC is similar to robot-assisted radical prostatectomy; however, the ports are placed more cephalad and an additional 15-mm port is placed in the left inferior quadrant. *4th*, fourth robotic arm; *As*, assistant port; *Cam*, camera; *Rb*, robotic arm.

A 15 mm Hg pneumoperitoneum is created with a 2-mm MiniPort and is maintained at this pressure, even during active suction, by a high-flow insufflator. Six transperitoneal ports (four ports of 8 mm for the robot) are placed more cephalad than the port position commonly used for robotic prostatectomy, with the camera port placed in the midline, 5 to 10 cm above the umbilicus (Fig. 28.1B). A 15-mm port is placed in the left iliac fossa and a 12-mm port is placed in the upper left quadrant; the positioning of these two ports is important for allowing a favorable angle for the staplers during small bowel transection and reconstruction, as well as for the removal of lymph nodes in packets, according to node templates dissection. This configuration allows for the dissection of the urachus, extended or superextended lymphadenectomy (if necessary), and adequate intestinal mobilization. With the patient placed in steep Trendelenburg, the robotic platform da Vinci Si Surgical System is then positioned between the patient's legs and the robot is docked. The first assistant stands on the left side of the patient.

Anatomic Orientation

Upon initial inspection, the surgeon must identify five important landmarks:

1. The medial umbilical ligaments
2. The peritoneal folds overlying the ureters close to the bladder
3. The vasa on each side
4. The posterior cul-de-sac of the rectovesical pouch

5. The iliac vessels

Identification of these landmarks is essential because it allows for precise orientation throughout the procedure and expeditious dissection.

Mobilization and Division of the Ureters

The ureters are identified at the level where they cross the iliac vessels and the posterior peritoneum is incised. The ureters, along with their surrounding fat, are dissected distally until their insertion into the bladder. It is important to maintain an adequate cover of periureteric fatty tissue. Close to the vesicoureteric junction, the superior vesical artery and the vas deferens are visualized crossing the ureter. These are mobilized away from the ureteric surface to obtain maximum ureteric length. The ureters are then divided just before they enter the bladder (prior to the ureteral orifice) between Hem-O-Lok clips and a sample of each proximal portion is sent for pathologic assessment. The Hem-O-Lok clips on the bladder side of the transected ureter serve as critical landmarks during the subsequent dissection, as they provide a readily identifiable visual clue during transection of the lateral pedicles. The ureters remain clipped throughout the procedure to create proximal ureteral hydrodistention, which facilitates later ureteroenteric anastomosis.

Retrovesical Dissection

With the robotic arm retracting the bladder anteriorly, the lateral peritoneotomies of the rectovesical pouch that were previously performed are now joined across the midline. It is important that the peritoneotomy across the cul-de-sac be created distally, such that it is only 1 to 2 cm anterior to the surface of the rectum. Often, there is a subtle transverse peritoneal fold at this location (we refer to it as the “second peritoneal fold”). This plane is now developed between the vasa and seminal vesicles anteriorly and the anterior surface of the rectum posteriorly. The vessels supplying the seminal vesicles are controlled, and bilateral vasa and vesicles are maintained en bloc with the bladder. Continued dissection brings the posterior layer of Denonvilliers fascia into view, which is incised with cold Shears (monopolar curved scissors) to reveal the yellow prerectal fat posterior to the prostate. This is an important landmark guiding the posterior dissection; the plane must remain between the prostate anteriorly and the prerectal fat posteriorly toward to the prostate apex, thus minimizing chance of rectal injury (Fig. 28.2).

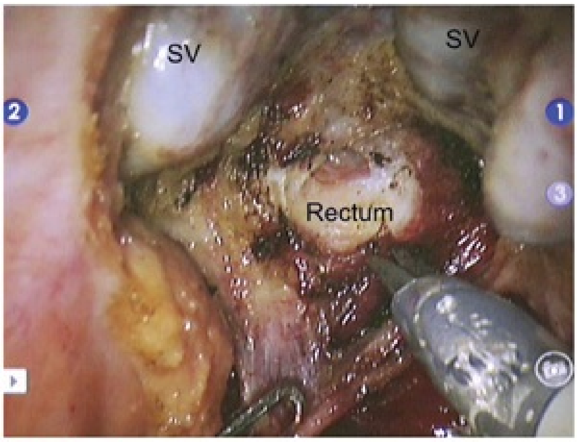


FIGURE 28.2 Dissection of the rectovesical space. The bladder is retracted anteriorly by the fourth arm, and a plane between the prostate (anterior) and prerectal fat (posterior) is developed toward the apex of the prostate. *SV*, seminal vesicles.

Lateral Dissection of the Bladder and Control of Vascular Pedicles

The parietal peritoneum lateral to the medial umbilical ligaments is incised from the vas deferens as it crosses the pelvic brim toward the peritoneotomy across the rectovesical cul-de-sac. The vasa are clipped and divided at the pelvic brim. The space between the bladder and the lateral pelvic wall is now developed bluntly, retracting the bladder medially away from the iliac vessels and the obturator nerve. As the bladder is still anteriorly attached to the abdominal wall, this allows the lateral pedicles to be clearly identified bilaterally. The lateral pedicles are now divided with 60-mm laparoscopic vascular staplers (Fig. 28.3). Once again, the two clips on the bladder end of the transected juxtavesical ureters serve as critical landmarks for the anteromedial limit of resection; the laparoscopic stapler is deployed just posterolateral to these clips. Usually, two or three stapler cartridge firings are necessary on each side to control the entire width of the lateral pedicles down to the endopelvic fascia on either side.

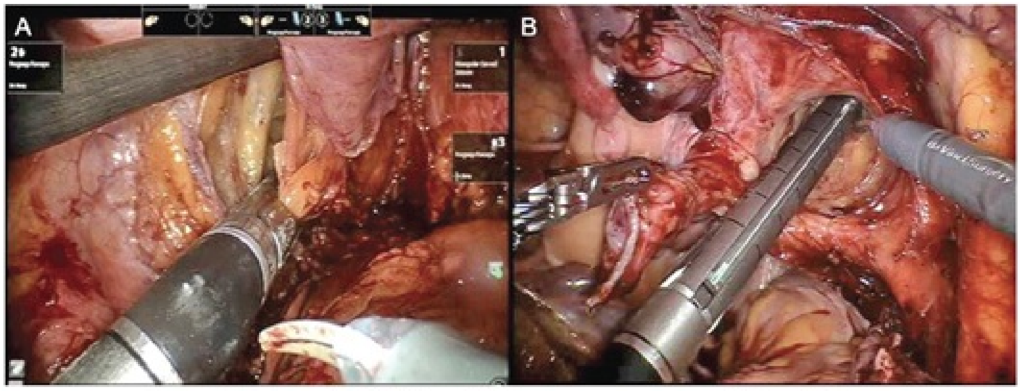


FIGURE 28.3 Ligation of the left bladder pedicle during cystoprostatectomy (A) and of the right bladder pedicle during anterior pelvic exenteration (B), with the use of a vascular stapler.

The posterior pedicles are now visualized coursing from just lateral to the rectum toward the urinary bladder. These are controlled with the stapler or divided between sequentially applied Hem-O-Lok clips. Usually, only the cephalad part of the posterior pedicles can be controlled at this stage; the caudal aspect is addressed after releasing the bladder from the anterior abdominal wall and completing the anterior dissection. At this point, the dissection is within proximity to the anterolateral surface of the rectum.

Anterior Dissection

A liberal inverted U incision is made with the hot Shears electrocautery, starting lateral to each medial umbilical ligament, with the limbs of the U joined anteriorly across the midline at the umbilicus. The urachus and medial umbilical ligaments are divided just caudal to the umbilicus. The bladder is dynamically pulled posteriorly, an avascular plane between the muscles aponeurosis and prevesical fat is dissected caudally toward the pubic bone and endopelvic fascia. The bladder is then released from the anterior abdominal wall; care is taken to protect the inferior epigastric vessels as they course up from the external iliac vessels to enter the posterior rectus sheath.

The space of Retzius is developed behind the pubic bone. Areolar tissue is dissected away to expose the anterior surface of the prostate and the endopelvic fascia on each side. The endopelvic fascia is incised down to the region of the dorsal venous complex. The superficial dorsal vein is coagulated and the fat overlying the anterior surface of the prostate is cleared off with the bipolar forceps. The puboprostatic ligaments are divided with cold Shears.

Transection of Dorsal Vein Complex and Membranous Urethra and Specimen Entrapment

The dorsal vein complex (DVC) is now ligated, using a 0-Vicryl on a CT-1 needle and carefully transected with cold scissors toward the anterior surface of the urethra. The remaining posterior pedicles are then clipped and divided. If an orthotopic neobladder reconstruction is planned, a long urethral stump is required. Thus, a meticulous dissection with small cuts surrounding the urethra is performed, releasing the urethra from the prostate apex. An anterior urethrotomy is performed, and the Foley catheter is then divided between Hem-O-Lok clips to avoid local spillage of urine. The urethra is now transected just proximal to the verumontanum and biopsies of the proximal and distal urethra are sent for frozen section evaluation. The free specimen is entrapped in an Endo Catch bag (II Endo Catch bag 15 mm) and parked in one side within the abdomen for later retrieval.

MODIFICATIONS FOR NERVE-SPARING CYSTECTOMY IN MEN

Once the ureters are divided and posterior dissection commences, care is taken to stay closely along the surface of the seminal vesicles, as the neurovascular bundles run lateral to the apical tip of the vesicles distally toward the prostate-vesicular junction. Thermal energy is avoided in the vicinity of the bundles. The plane of dissection is closer to the bladder and further away from the rectum. The bundle on either side is dissected away with cold Shears, and hemostasis is secured with Hem-O-Lok clips. This is in contrast to the non–nerve-sparing technique, in which a laparoscopic stapler is used for en masse transection of the lateral pedicle more posterolaterally, closer to the rectum, and at a considerable distance from the bladder. During the anterior dissection, the endopelvic fascia is maintained intact, and the lateral pelvic fascia is incised high on the prostate to drop the bundles posteriorly. The DVC is then divided as previously described. The bundles on either side are released from the prostate apex using cold Shears, and the urethra is divided. The remainder of the operation proceeds in the usual fashion.

MODIFICATIONS FOR CYSTECTOMY IN WOMEN

Pelvic Exenteration

For cystectomy in women, the procedure begins with the dissection of the ureters as previously described. The uterus is pulled proximally by the fourth robotic arm and Endo GIA staplers transect the infundibulopelvic ligaments and the uterine arteries. An incision is made in the posterior peritoneum near the uterine cervix. A stick sponge previously inserted into the vagina facilitates visualization of the vaginal fornix (Fig. 28.4). The remaining posterior dissection and the vaginal incision are made after preparing the DVC. The lateral pedicles are transected with laparoscopic staplers and the bladder is dropped in the usual fashion as described earlier. The DVC is suture-ligated with a 2-0 polyglactin suture on a CT-1 needle.

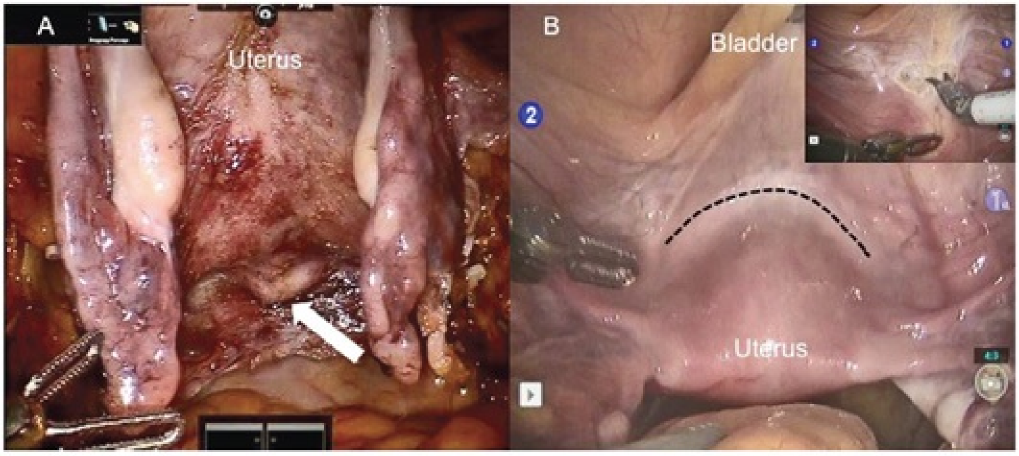


FIGURE 28.4 Cystectomy in women. **A:** During anterior pelvic exenteration, gauze is inserted in the vulva to help identify the vagina (*arrow*). **B:** In reproductive organ–sparing cystectomy, the dissection is created between the bladder and the uterus (*dotted line* and *insert*).

Attention is now returned to the posterior dissection. With the uterus anteverted, a transverse incision of the posterior vaginal fornix is completed at the previously scored site. The vaginal incision is extended distally on either side of the urethra, excising a narrow central strip of vagina en bloc with the bladder specimen. Using a perineal approach, the external meatus and distal urethra are circumferentially cored out using electrocautery. The urethra is then resected along with the bladder, the anterior two-third portion of the vagina, the uterus, and the ovaries. The specimen is entrapped in an Endo Catch bag and extracted through the vulva (Fig. 28.5). A minipad is placed in the vulva to minimize the loss of CO_2 and the pneumoperitoneum is maintained by a high-flow insufflator. These allow for vaginal reconstruction using 2-0 V-Loc sutures on a CT-1 needle via robotic technique before proceeding with urinary diversion.

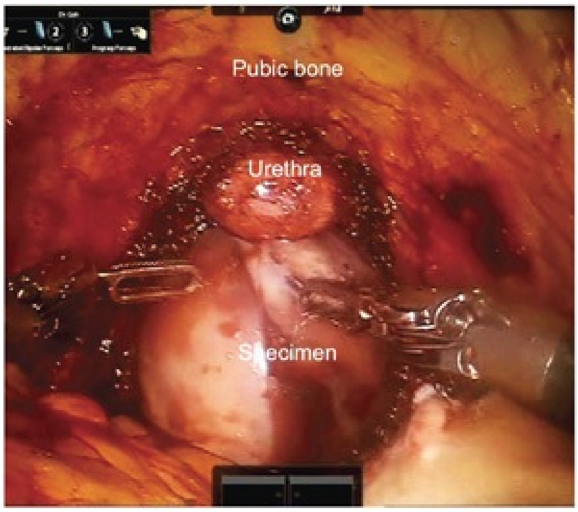


FIGURE 28.5 In women, an excellent choice for extraction of the surgical specimen is through the vagina. If an orthotopic neobladder is planned for UD, an adequate urethral stump is preserved.

If a urinary orthotopic neobladder reconstruction is planned, the distal urethra must be preserved (Fig. 28.5). Thus, the urethra must be carefully dissected and sectioned allowing for a sufficiently long stump for neobladder-urethral anastomosis. In these cases, it is recommended to pad the remainder of the vagina with the omental patch positioned between the neobladder and the vagina to prevent urinary fistula formation.

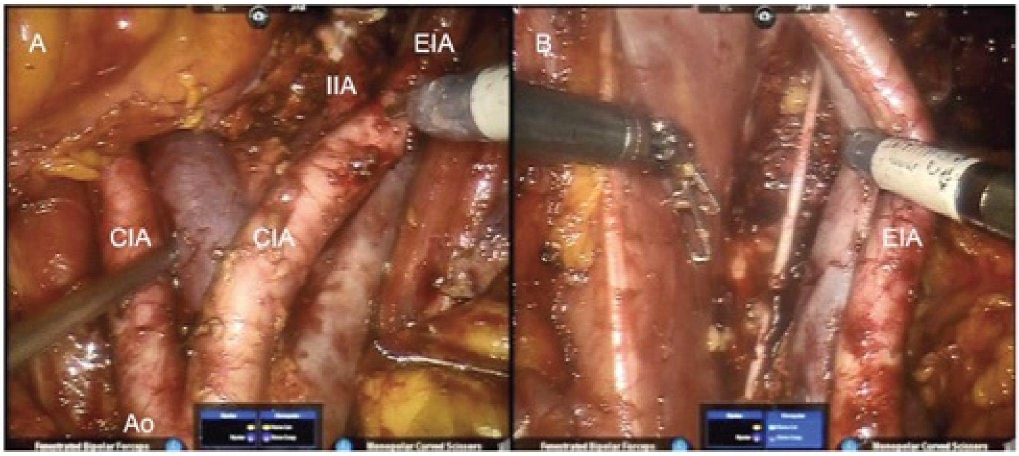
REPRODUCTIVE ORGAN–SPARING CYSTECTOMY

In carefully selected, sexually active women with less aggressive organ-confined disease, a reproductive organ–sparing cystectomy can be an option. In these cases, the suspensory ligaments of the ovaries and the uterine arteries and ligaments are preserved. Precise dissection of the bladder away from the uterus and vagina is critically important. With a stick sponge inserted through the vulva, the vagina is pulled posteriorly and the uterus is retroverted using the robotic fourth arm. The bladder is identified, and the peritoneum on the anterior surface of the uterus is incised transversely using hot scissors (Fig. 28.4). With the bladder now retracted anteriorly, dissection is performed along and close to the anterior surface of the uterus, developing this avascular plane. Typically, dissection proceeds smoothly until the cervix is reached, where adhesions are often dense. At this point, care is taken not to thin the vaginal wall or enter the bladder. This dissection is carried distally down to the bladder neck, which is the landmark of posterior dissection. Anterior dissection is now performed and the lateral pedicles are divided with a stapler. The urethra is prepared in the usual fashion and the rest of the procedure is followed as previously described. As the vagina is not opened, the specimen is entrapped in an Endo Catch II bag for later retrieval.

EXTENDED AND SUPEREXTENDED LYMPHADENECTOMY

Surgical Technique

Although the extent of lymphadenectomy is debatable, it is noteworthy that not only the lymph node yield but also the quality of resection, including skeletonization of the arteries is important (16). Also relevant is the ligation of the larger lymphatic vessels to prevent formation of lymphocele or chylous ascites, and care must be taken to avoid cutting into any enlarged lymph nodes to minimize the risk of tumor spillage. We perform lymph node dissection after the robotic cystectomy. The landmarks (template) for superextended lymphadenectomy are distally the lymph nodes of Cloquet, laterally the genitofemoral nerve, medially the perivesical fat, and proximally the inferior mesenteric artery (IMA). Therefore, the anterior surface of the aorta and vena cava up to the IMA, along with the para-aortic, preaortic, interaortocaval, precaval, and pericaval lymphatic fatty tissue/nodes, are excised. The aortic bifurcation and the presacral area are also dissected (17). The technique mimics the “split-and-roll” technique used during ORC. Right lymphadenectomy is performed first. Using the 30-degree camera lens, the lymphadenectomy begins distally with the dissection of the lymph nodes of Cloquet. It then continues proximally toward the bifurcation of the aorta up to the IMA (Fig. 28.6A). To obtain a good dissection of the obturator fossa, lateral dissection is necessary up to the external iliac vessels allowing for direct visualization of the obturator nerve (Fig. 28.6B). The right ureter should be dissected cranially to avoid inadvertent proximal damage. The lymphadenectomy then continues in the left pelvic region, which is initially performed from proximal to distal (aorta to iliac vessels), as opposed to the technique on the right side. The mesosigmoid is retracted laterally to the left allowing lymphadenectomy of the left internal iliac vessels and presacral region. This maneuver facilitates the creation of a “window” below the sigmoid colon for later transposition of the left ureter to right during ureteral bowel anastomosis (Fig. 28.7). The remainder of the left pelvic lymphadenectomy is performed in the same fashion as the right lymphadenectomy. The sigmoid colon is now retracted to the right and the dissection begins distally and continues proximally toward the already skeletonized internal iliac vessels. The removal of the lymph nodes occurs in packets, according to the templates, and the nodes are placed in the appropriate bag at the time that each region is dissected, as this may influence the number of lymph nodes removed (18).


A
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Fenestrated Bipolar Forceps
Monopolar Curved Scissors
Fenestrated Bipolar Forceps
Monopolar Curved Scissors

FIGURE 28.6 **A:** Extended pelvic lymphadenectomy. Note the "skeletonization" of the external iliac arteries (*EIA*), internal iliac arteries (*IIA*), common iliac arteries (*CIA*), and proximal lymph node dissection extension above the aortic (*Ao*) bifurcation. **B:** Lymphadenectomy of the left obturator fossa.

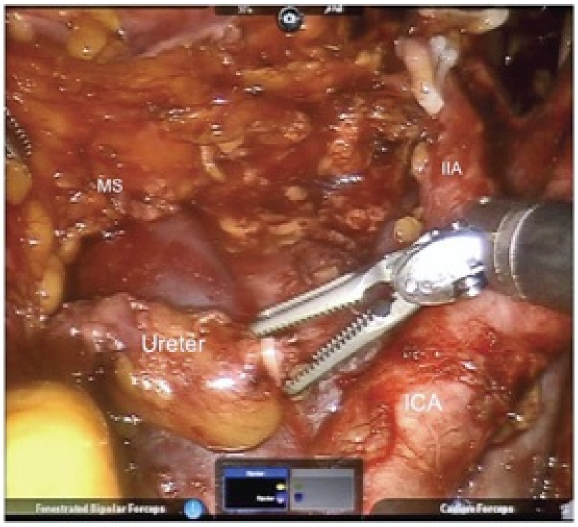

FIGURE 28.7 During the course of lymphadenectomy, a "window" in the mesosigmoid (*MS*) is created to allow the passage of the left ureter from left to right. *CIA*, common iliac artery; *IIA*, internal iliac artery.

URINARY DIVERSION

Surgical Technique

Intracorporeal Orthotopic Ileal Neobladder

In order to create a spherical orthotopic ileal neobladder (OIN) with a good filling capacity while maintaining a low pressure, the principles of ORC should be replicated and applied to the robotic approach (19,20). Here, we describe our updated technique for OIN (20). For the urinary diversion (UD), the use of atraumatic Cadiere forceps instead of a ProGrasp Forceps is essential to avoid intestinal injury during bowel manipulation.

Isolation of the Small Bowel Intestine

A total of 65 cm of small bowel segment is isolated as follows: 44 cm of the reservoir, 16 cm of the chimney, and 5 additional cm are discarded ("discarded segment") during the small bowel anastomosis (Fig. 28.8). Using the 30-degree camera lens, the first step in creating the neobladder is to identify a loop of ileum that reaches the urethra without tension, which is usually located 25 to 30 cm proximal to the ileocecal valve. This point is marked with a 3-0 V-Loc barbed stitch in the antimesenteric edge of the bowel and it will be the site of neobladder-urethral anastomosis. This is a major step of the UD because it saves time and ensures the feasibility of performing neobladder-urethral anastomosis without tension. From this point, we measure 11 cm distally (toward to the ileocecal valve) and 11 cm proximally (total 22 cm). The use of a previously metered Penrose is important because it ensures accurate measuring and, because it is malleable, it facilitates intracorporeal manipulation. This point (22 cm) is marked with an undyed 2-0 Vicryl and is pulled distally toward the pelvis by the fourth arm (denoting the apex of the posterior plate). An additional 22 cm is measured proximally to this point (total 44 cm) and is also marked with an undyed 2-0 Vicryl to signify the end of the reservoir and beginning of the chimney. An additional 16 cm (total: 60 cm) is measured proximal to this point (44 cm) for the chimney. Finally, 5 cm (total: 65 cm) of proximal ileum ("discarded segment") is resected and discarded. This discarded segment helps "keeping out" the neobladder, preventing neobladder-bowel fistula, and ensuring good vascularization to the ends of the bowel during the intestine reconstruction (anastomosis). To avoid confusion during the intestine reconstruction, the ends of the intestine are marked with undyed Vicryl for the UD (*u*ndyed for *U*D) part and with dyed Vicryl for the gastrointestinal part.

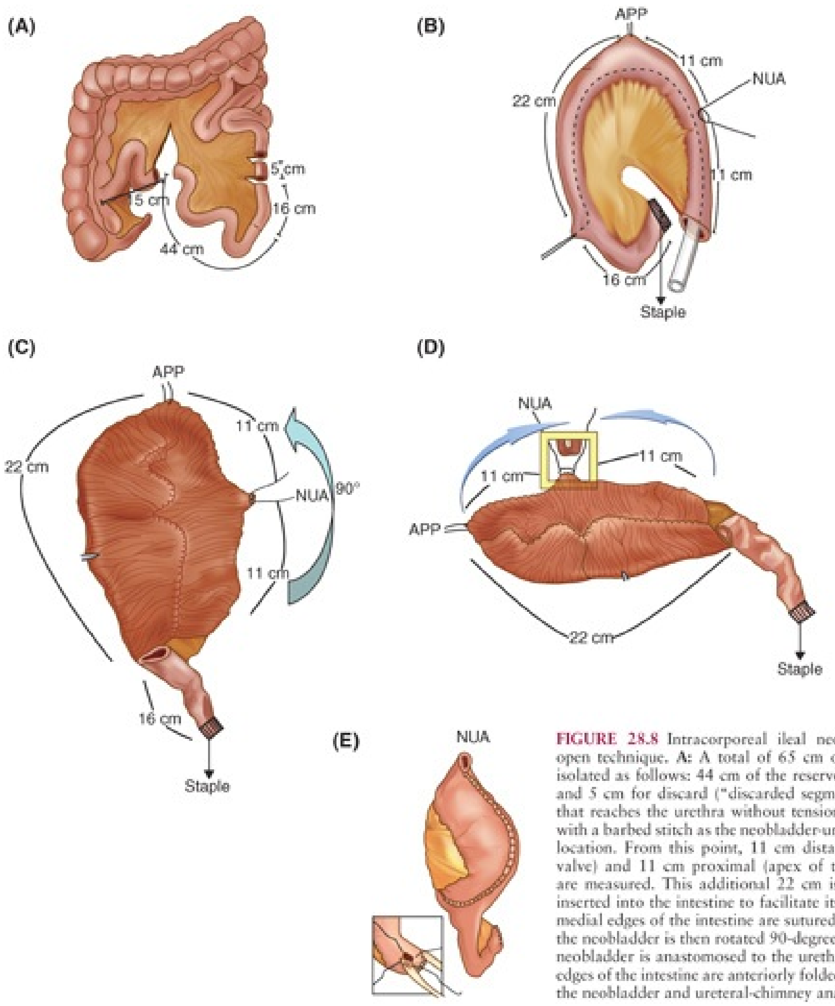

FIGURE 28.8 Intracorporeal ileal neobladder: duplicating the open technique. **A:** A total of 65 cm of small bowel segment is isolated as follows: 44 cm of the reservoir, 16 cm of the chimney, and 5 cm for discard ("discarded segment"). **B:** A loop of ileum that reaches the urethra without tension is identified and marked with a barbed stitch as the neobladder-urethral anastomosis (*NUA*) location. From this point, 11 cm distal (toward to the ileocecal valve) and 11 cm proximal (apex of the posterior plate [*APP*]) are measured. This additional 22 cm is marked. A chest tube is inserted into the intestine to facilitate its detubularization. **C:** The medial edges of the intestine are sutured and the posterior plate of the neobladder is then rotated 90-degree counterclockwise. **D:** The neobladder is anastomosed to the urethra (*square*) and the lateral edges of the intestine are anteriorly folded. **E:** Final configuration of the neobladder and ureteral-chimney anastomosis (*insert*).

Inserting a 60-mm laparoscopic stapler through the 15-mm port in the left iliac fossa allows for a good angle for isolation and reconstruction of the small bowel intestine. Normally, one cartridge of staples is enough to allow adequate bowel mobilization without compromising its vascularization. Indocyanine green ("firefly") can be used to facilitate visualization of mesentery vascularization and ensure no vascular injury occurred while firing the stapler through the bowel and mesentery (Fig. 28.9). The isolated intestinal segments are now properly marked and transected, and the surgery proceeds with the bowel continuity reconstruction. For this, the suture lines of the staples are removed, the bowel edges are aligned, and the side-to-side intestinal anastomosis is performed with the 60-mm laparoscopic stapler firing along the antimesenteric border and then across the open intestinal borders. The mesenteric window is closed with an interrupted suture.

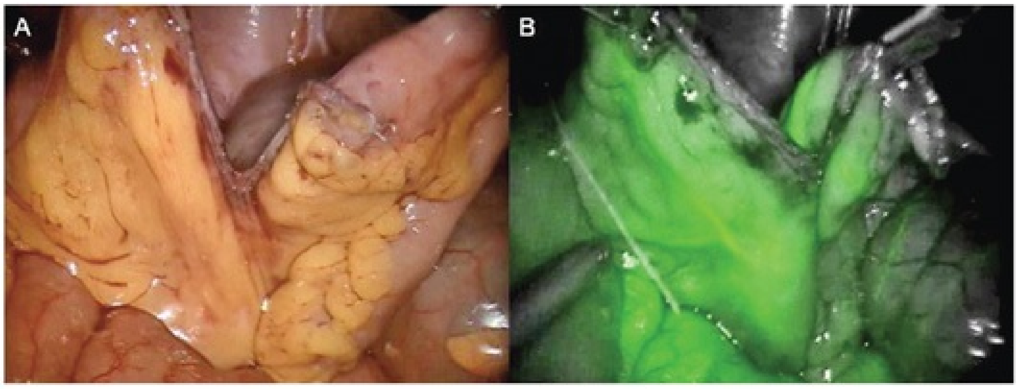

FIGURE 28.9 A: Bowel division using intestinal stapler. B: The use of Indocyanine green ("green dye") under infrared light permits the identification of mesentery vascularization.

Bowel Detubularization and Suture of the Posterior Plate of the Neobladder

With the fourth robotic arm pulling the 22-cm point (apex of the posterior plate) toward the pelvis, a 24Fr chest tube is inserted through the 12-mm port in the upper left quadrant and inserted into the small intestine. This greatly facilitates the longitudinal opening of the intestine (with hot scissors) in the antimesenteric border but near to the medial part of the mesentery. The medial edges of the intestinal segments are aligned and interrupted sutures (2-0 Vicryl) are placed to allow handling and symmetry of the pouch. A running suture using a 2-0 V-Loc stitch on a CT-1 needle is carried out from distal to proximal and the posterior plate of the neobladder is created. A "free-hands" suture is performed during the entire pouch creation and, in order to save time, it can be facilitated by (a) the assistant pulls the stitch with the hook for every needle during the running suture and (b) the use of a barbed V-Loc stitch avoids losing the stitches, therefore keeping the suture line watertight.

Neobladder-Urethral Anastomosis and Folding the Pouch

After suturing the posterior plate of the neobladder, it is rotated 90 degrees counterclockwise to align the previously placed 3-0 V-Loc stitch (neobladder-urethral anastomosis point; 11 cm) with the urethra. At this point, the antimesenteric edge that was previously marked with 3-0 V-Loc is sutured to the distal Denonvilliers fascia, adjacent to the rectourethralis muscle, to decrease tension on the anastomosis. The urethra-neobladder anastomosis is then performed with a double-armed 3-0 Monocryl suture on a RB-1 needle. The anastomosis begins at the posterior edge of the urethra ("6 o'clock") and continues anteriorly in a running fashion over a urethral catheter (22Fr Couvelaire) (Fig. 28.10). The anastomosis is completed when the left and right running sutures reach the midline. This is followed by the anterior folding of the lateral edge of the intestine, performed by a running suture using barbed 2-0 V-Loc on a CT-1 needle to create a spherical configuration for the neobladder. A small opening is left in the anterior suture line to allow passage of bilateral ileoureteral stents.

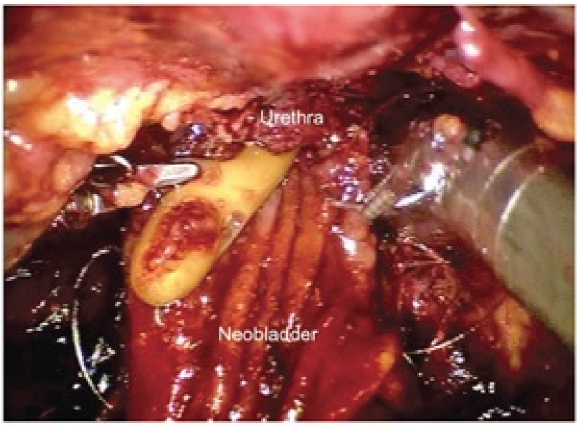

FIGURE 28.10 Neobladder-urethral anastomosis.

Ureteral-Chimney Anastomoses

For ureteral anastomoses using the chimney of the neobladder, the distal parts of the ureters that were clipped with Hem-O-Loks are resected. A guide wire is inserted through a 2-mm MiniPort located in the right inferior quadrant to facilitate insertion of a 7Fr double-J ileoureteral stent (Fig. 28.11). The ureters are spatulated and separately anastomosed over the stents at the antimesenteric border of the chimney using 4-0 Vicryl on a RB-1 needle with interrupted sutures as described by Bricker (21). A running suture using 3-0 Vicryl is performed at the proximal end of the chimney to avoid contact of urine/mucus with the staples, preventing stone formation. The remaining portion of the pouch that was left open is now closed and 180 mL of saline is injected into the neobladder to confirm no leak (Fig. 28.12). A closed suction drain system is inserted through the portal in the right iliac fossa and positioned in the pelvis.

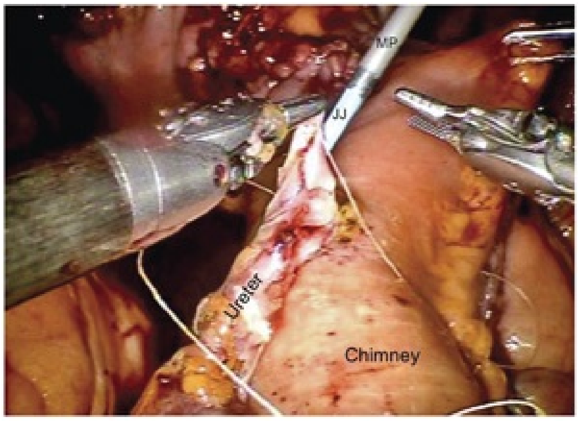

FIGURE 28.11 During the ureteral-chimney anastomosis, a double-J ureteral stent (*JJ*) is inserted into the ureter through a 2-mm MiniPort (*MP*) punctured in the right inferior abdominal quadrant.

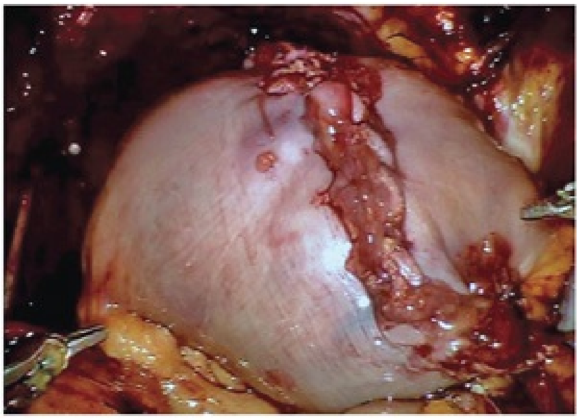

FIGURE 28.12 The spherical final aspect of the OIN performed entirely intracorporeal using robot assistance.

The previously bagged specimen is removed through an enlargement incision in the midline camera port (or through the vagina in women as previously described). The port placement incisions are sutured with the Carter-Thomason CloseSure System, and the patient is sent to the recovery room.

Intracorporeal (Bricker) Ileal Conduit

For the urinary ileal conduit (IC), a stoma site is marked prior to RARC for all patients by an enterostomal therapist in a location separate from the patient's skin folds or bone eminences (21). The technique for the intracorporeal robotic IC replicates the open procedure with a few minor modifications (7). A 15-cm ileal segment 15 cm proximal to the ileocecal valve is isolated using two applications of 60-mm laparoscopic staples; the isolated segment is then dropped posteriorly. Ileoileal continuity is restored with a side-to-side anastomosis using the Endo GIA stapler, as described earlier for the ileal neobladder. The mesenteric window is closed with interrupted suture. The proximal end of the conduit is closed with a 3-0 Vicryl running suture to exclude the staples, avoiding their contact with urine/mucus and preventing stone formation. The distal ends of the ureters are spatulated and two separate anastomoses are performed over 7Fr double-J ileoureteral stents using interrupted sutures as described earlier. The stoma is then fashioned for IC maturation. With Allis forceps, the assistant holds and pulls out the distal part of the IC. The staple line of the distal part of the ileal segment is resected and the IC is matured in the previously marked location on the patient's skin. The ports are then closed and the drain is placed as previously described for the neobladder.

POSTOPERATIVE CARE

Immediately after surgery, the patient is sent to the recovery room and then to the intensive care unit. The nasogastric tube is removed and intravenous fluids are continued until bowel function is regained. Per oral diet is progressive according to the patient's tolerance. The antibiotic is discontinued during postoperative day (POD) 1. Patients are encouraged to ambulate early and the neobladder is gently irrigated with 50 mL of saline every 4 hours to prevent plugging of the catheters by mucus. The drain is removed when its output is less than 150 mL per 24 hours and the liquid analysis is not compatible to urine. A cystography is routinely performed at POD 21 and urethral and ureteral catheters are removed if there is no leakage (Fig. 28.13).

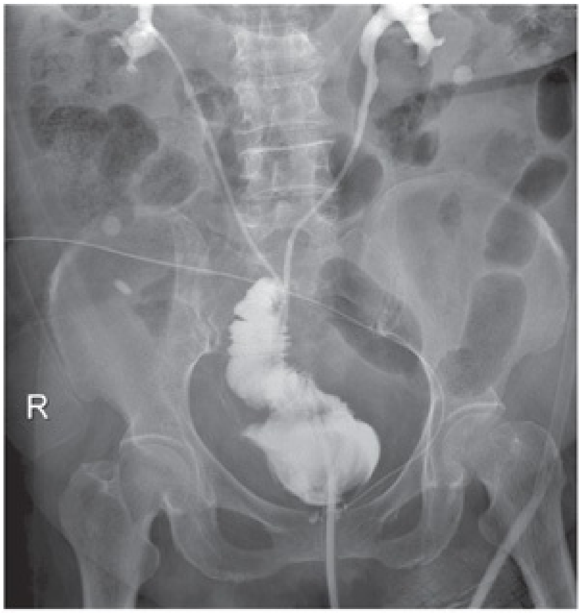

FIGURE 28.13 Cystogram on POD 21.

ONCOLOGIC OUTCOMES

Overall

RARC is a relatively recent procedure; thus, there is a paucity of studies reporting long-term outcomes in a large cohort of RARC patients. Khan et al. (22) reported on oncologic outcomes ranging from 5 to 8 years of follow-up for a cohort of 14 patients undergoing RARC. They report a disease-free survival of 50%, a disease-specific survival of 75%, and an overall survival of 65%, and none of these patients experienced deterioration in renal function. Although the authors report that they found it difficult to properly perform pelvic lymphadenectomy because they used the first-generation da Vinci robot, they concluded that the 5-year oncologic outcomes are equivalent to those reported by a robust series of ORC (18,22). A recent study reported the oncologic outcomes of the longest follow-up to date for patients undergoing RARC ($n = 17$) or LRC ($n = 104$). The majority of the tumors were urothelial carcinomas (81%) and muscle invasive (≥ pT2 in 67%). The positive soft tissue margins rate was 6.6% and 20% of the patients had lymph node metastasis on final pathology. With a median follow-up of 5.5 years, 48% of the patients were disease-free and 23% died from BCa. The actuarial 10-year recurrence-free survival was 54%, cancer-specific survival was 63%, and overall survival was 35% (23). These results are similar to those reported for ORC (24).

The oncologic outcomes of RC depend on many factors such as disease stage, surgical margins, and lymph node metastases (14,25). Compared to ORC, the gold standard, RARC does not appear to be inferior in terms of surrogate oncologic outcomes (positive surgical margins and number of lymph nodes resected) or perioperative complications. Additionally, RARC has the benefit of decreased blood loss and transfusion rates but a longer operative time (10,26–28) than ORC. Although enrolling a small number of patients, Parekh et al. (27) conducted a prospective randomized clinical trial comparing the results of RARC ($n = 20$) versus ORC ($n = 20$) and reported no difference between the groups in terms of operative time, hospital stay, postoperative complications, pathologic staging, positive surgical margins (5% for each group), or number of lymph nodes resected; the RARC group had, however, less blood loss. Similar results were reported by Nix et al. (26); however, a longer operative time was reported for the RARC group. Additionally, they demonstrated other benefits of a minimally invasive approach such as shorter time to bowel movements and flatulence and a decreased need for postoperative analgesia.

SURGICAL MARGINS

Positive surgical margins (PSM) in the soft tissue of RC specimen are an independent risk factor for local recurrence, disease-specific survival, and overall survival (29,30). Due to the lack of tactile feedback in the robotic approach, PSM could be an important issue for RARC. In this regard, a multi-institutional study evaluated 513 surgical RARC specimens and reported a PSM rate of 6.8%. The authors reported that older patients, number of metastatic lymph nodes, and pathologic stage were independent risk factors for PSM. In fact, the rate of PSM was 1.5% for pathologic stage ≤ pT2, 8.8% for pT3, and 39% for pT4. There was no significant association with PSM rate and the number of surgeries performed per institution or per surgeon (25). These findings are comparable to those of the ORC (29,30).

LYMPHADENECTOMY

Pelvic lymphadenectomy should be performed during RC because it promotes better accuracy of pathologic staging and may impact oncologic outcomes (31). Many factors such as lymphadenectomy extension (extended or superextended), lymph nodes yield, or quality of lymphadenectomy could potentially present limitations for proper robotic lymphadenectomy (RAL) for BCa (16,31). However, recent studies have shown and demonstrated that RAL can be of excellent quality and quantity, even in challenging cases such as postradiotherapy or after abdominal vascular graft placement (12,32–36).

In a unique study, Davis et al. (32) performed RAL in 11 patients who were subsequently converted to open lymphadenectomy to assess the amount of additional lymph nodes that could be removed with the open approach. The results showed that the median number of lymph nodes dissected by RAL was 43 (range: 19 to 63) and the subsequent open lymphadenectomy was able to dissect a median of 4 (range: 0 to 8) additional nodes. This gave a yield of 93% for RAL in relation to the open lymphadenectomy. Another study compared the RAL in 35 patients versus open lymphadenectomy in 120 patients; Abaza et al. (33) found no difference in lymph node yield between the two approaches (RAL = 37.5 versus open = 36.9, $p = 0.68$). Furthermore, only 6% of patients undergoing RAL and 10% of open lymphadenectomy patients had less than 20 lymph nodes retrieved. The authors concluded that the quality of RAL is equivalent to the open lymphadenectomy.

FUNCTIONAL OUTCOMES

There is minimal literature reporting the functional outcomes following RARC. Tyritzis et al. (37) reported the functional outcomes of 70 patients (62 males and 8 females) who underwent RARC and intracorporeal OIN. Of the patients who underwent nerve-sparing cystoprostatectomy, 81.2% were potent (erections adequate for penetration) with ($n = 16$, 50%) or without ($n = 10$, 31.2%) the use of PDE5-I at 1-year follow-up, and four out of the six females evaluated on follow-up were sexually active. The 1-year daytime and nighttime continence (use of 0 to 1 pad per day) rate was 88.2% and 73.5%, respectively (37).

URINARY DIVERSION

Currently, there is still no consensus about the best UD following RC; therefore, UD should be individualized according to the patient's characteristics and expectations (38). Although cystectomy and lymphadenectomy are standardized procedures and are more likely to be performed using a minimally invasive approach with an acceptable operative time, intracorporeal urinary diversion (IUD) poses a larger challenge. In fact, laparoscopic IUD is laborious, leading to prolonged operative time, and thus more likely to be performed by selected dedicated and skilled surgeons (5,6,39,40). This has led to the abandonment of laparoscopic IUD by several groups and it is performed extracorporeally by a small laparotomy (40,41).

Although the emergence of the robotic platform, specifically with EndoWirst system, has greatly improved the ergonomics and facilitated intracorporeal reconstructive urologic surgery, the vast majority of UD is still being performed extracorporeally and IC is the diversion of choice in up to 90% to 97% of RARC (9,42–46). In fact, RARC is more likely to be performed in urban locations, teaching hospitals, and by high–annual volume surgical hospitals and surgeons (9,10).

Beecken et al. (47) reported the first case of robotic IUD (RIUD) with an ileal neobladder in 2003; it was a successful procedure with a duration of 8.5 hours. More than 10 years after the first report of RIUD, there have been around 219 RIUD neobladders reported to date and the average operative time still ranges from 7 to 9.9 hours (20,37,44,46–49). Most authors performing robotic intracorporeal neobladder sought to reproduce the principles of the open technique, such as length of bowel and good filling capacity while maintaining a low pressure, as described by Studer et al. (19,20,37,42,48,49). Data of 935 RARC patients from the International Robotic Cystectomy Consortium comparing IUD versus extracorporeal urinary diversion (EUD) demonstrated that IUD was performed in 167 (18%) patients (IC = 106 [11%], neobladder = 61 [7%]) and EUD in 768 (IC = 570 [61%], neobladder = 198 [21%]) patients. Of the 18 institutions' members of the Consortium, 10 performed the UD solely by open approach. Interestingly, the operative time (414 minutes), estimated blood loss, and hospitalization were not significantly different between IUD and EUD. However, the 30-day (5% versus 15%, $P < .001$) and 90-day (12% versus 19%, $P = .016$) readmission rates and the 90-day (1.6% versus 4.9%, $P = 0.043$) mortality rate were lower for the IUD group. On multivariable logistic regression analysis, the type of UD (continent versus conduit) was a predictor for the likelihood of a complication (odds ratio: 1.5 [95% CI], $P = .04$) but the location of UD (intracorporeal versus extracorporeal) was not (odds ratio: 1.04 [95% CI], $P = .859$) (46).

Some authors use titanium staples to create laparoscopic or robotic neobladders (39,41,50,51). The use of staplers may facilitate creating the reservoir and may save operative time. The main concern with this technique is the stone formation and functional outcomes of these reservoirs. In fact, Leslie et al. reported an 8% rate of stone formation in 983 patients with three types of orthotopic neobladders in open surgery (52). The results demonstrated a significant difference between the rate of stone formation between the T-pouch (9.6%) and Kock urethra (9.9%), when staplers were used, and Studer (4.8%), with the findings similar to other series (11,51). However, studies with a larger patient cohort and longer follow-up are needed to better evaluate RIUD using staplers.

COMPLICATIONS

Although RARC can be technically demanding, the rate of conversion to open surgery for RARC approaches zero, but combine it with IUD and this rate can approach 5% (37,53). RC is a major surgery and is associated with high complication rates regardless of its approach (38,42). It is difficult to compare postoperative complications among RC series because the patients are subjected to different types of UD, that is, intra- or extracorporeal and IC or OIN. Although a majority of studies report 30-day and 90-day postoperative complication using Clavien-Dindo system, there is a lack of standardization for reporting RARC complications (42,54,55). Overall, studies comparing RARC with ORC consistently demonstrated that RARC had less blood loss, required fewer blood transfusions, but were performed with a longer operative time. Furthermore, although there are differences among the studies, RARC is associated with superior, or at least not inferior, postoperative outcomes such as time to flatus; time to bowel movement; parenteral nutrition use; length of hospital stay; overall, minor or major complications; readmission rates; and perioperative deaths (9,10,26–28,56–59). These results were confirmed by a systematic review and meta-analysis of 962 patients that underwent RARC or ORC (59). A population-based study using the U.S. Nationwide Inpatient Sample compared the postoperative results of 1,444 ORC versus 224 RARC patients. The results demonstrated that the RARC group had fewer complications and deaths during hospitalization, with no statistically significant difference in length of stay. However, these results should be analyzed with caution because the characteristics of the tumors were not taken into account nor were the outcomes after the patients were discharged (10). Leow et al. (9) analyzed a population-based cohort of 34,672 ORC versus 2,101 RARC cases across 279 hospitals in the United States and reported that major complication rates were similar between the groups, but the RARC group presented with a 46% decreased risk for minor complications. Furthermore, the RARC group had shorter hospitalizations. Unfortunately, the study did not control for oncologic characteristics (9). Matched randomized prospective studies showed no significant difference between RARC and ORC patients regarding the length of hospital stay, postoperative complications, and mortality rate. However, due to the small number of patients analyzed, these studies have limited power for comparison (26–28). Ng et al. (58) compared 104 ORC versus 83 RARC patients and reported a higher complication rate for ORC versus RARC, 59% versus 41% ($p = 0.04$), respectively. The authors also reported a greater blood loss, transfusion rate, and longer hospital stay for ORC. They also found that the robotic approach was an independent predictor for fewer complications (58).

A study analyzing 939 RARC patients comprised from a multi-institutional international database reported that the majority of patients were men (80%) with an American Society of Anesthesiologists (ASA) score ≥3 (53%) and 47% had prior abdominal surgery. IC was the most performed UD (68%), and the UD was more frequently performed via the open approach (77%). The mean estimated blood loss and hospital stay were 400 mL and 8 days, respectively. Blood transfusions were required in 15% of patients. Within 90 days after surgery, 48% of patients experienced complications, 20% were readmitted, and 4.2% died. The most frequent complications were gastrointestinal (27%), followed by infection (23%), genitourinary (17%), and cardiac (10%). Increasing age, neoadjuvant chemotherapy, and blood transfusions were independent predictors for any and high-grade complications (42). It is noteworthy that body mass index, ASA score, comorbidity, and operative time have also been reported as independent predictors for postoperative complications (13,14,46,54,58). Two studies, from the same group, used a similar cohort of 196 and 209 RARC with EUD patients and found on multivariable analysis that orthotopic UD is an independent predictor for major complications (54,55). They found that patients undergoing IC had a decreased likelihood of complications compared to patients whom either had an Indiana pouch or an OIN substitute diversion despite the selection of a more comorbid population for IC (55).

LEARNING CURVE

Some studies have assessed the learning curve for RARC (60–62). Guru et al. (62) evaluated 100 consecutive cases of RARC and reported that the operative time decreased until the 16th case, where a plateau was reached. Pruthi et al. (61) demonstrated that oncologic results are satisfactory beginning with the first case in a series of 50 RARC cases and that the operative time and estimated blood loss both improved up to the 30th case, where significant differences were no longer observed. Hayn et al. (60) analyzed the learning curve for RARC by reviewing the data from 496 patients from 14 institutions consisting of 21 surgeons with prior experience for robotic-assisted radical prostatectomy. The authors divided the cases into three groups according to the experience of surgeons with RARC: those who performed <30, 30 to 50, or >50 RARC cases. They reported that the operative time decreases and the node yield increases with the surgeon's experience. They also estimated that 30 cases was an acceptable number for proficiency in performing RARC (60).

Azzouni et al. (63) reported on an initial experience of 100 consecutive cases of robot-assisted intracorporeal IC. The authors divided the patients into four groups of 25 and reported a statistically significant decrease in the UD time (140 to 103 minutes, *P* = .002) but a statistically significant increase in both the length of hospitalization (7 to 9 days, *P* = .014) and transfusion rate between the groups (from 0% to 24%, *P* = .025). No statistically significant difference was observed in total operative time or complications rate between the groups. This is in contrast to a study that evaluated the learning curve for RARC with RIUD in 45 patients divided into three groups. It found a reduction in complications, operative time, and length of hospital stay throughout the series. There was no significant difference in the number of nodes yielded or PSM rate (64).

QUALITY OF LIFE

RC significantly impacts all aspects of life, from financial impact to overall mental and physical well-being (65). As RARC gains popularity and becomes an accepted alternative for treatment of BCa, there is limited data available regarding the quality of life (QoL) for patients undergoing this burdensome surgery. Because of its recent advent, the reports within the literature discuss only the short-term impact (less than 1 year), and to date, no study demonstrates the long-term effects of RARC on QoL (66,67). Stegemann et al. (66) reported the short-term (90 days) health status for 91 RARC patients measured using the Convalescence and Recovery Evaluation (CARE), which encompasses four domains: pain, gastrointestinal, cognition, and activity. They found that RARC patients approached preoperative baseline levels within 90 days using the CARE in the total CARE, pain, cognition, and activity domains but not for the gastrointestinal domain. Poch et al. (67) used the Bladder Cancer Index and the Body Image Scale to determine the short-term QoL outcomes after RARC for 43 patients. They found that RARC patients were able to recover both the urinary and bowel domains in less than 6 months, but the body image perception and sexual function domains required more than 6 months and more than 16 months, respectively.

COSTS

The costs of a complex operation such as RARC can certainly be a limiting factor for many institutions. Assessing the cost of RARC is challenging because it can be influenced by several factors: logistical costs of operation, use of the robot, surgical equipment, operative time, hospital stay, complications, total recovery time, and long-term functional and oncologic outcomes, to name a few. Studies have shown that when compared to ORC, the direct cost for RARC is higher, and the higher cost of RARC is related to the supplies (9,10,68). However, when considered as a whole, RARC may be more cost-effective than ORC (69–71).

FINAL CONSIDERATIONS

As mentioned earlier, although RARC presents perioperative advantages in comparison to ORC, the length of hospital stay and postoperative complications still need to be improved. We advocate that decreasing operative time and using protocols such as ERAS are important targets to improve perioperative outcomes after RARC. Currently, there are no reports within the literature for the use of ERAS after RARC; however, the reports for ORC are encouraging (72). Another promising approach to decrease operative time and morbidity related to RARC is the use of bioengineered tissue for the UD. Preclinical results are encouraging and phase 1 clinical trials are ongoing (73–75).

PARTIAL CYSTECTOMY, URACHAL EXCISION

The urachus is a vestigial fibrous cord derived from involution of the allantois that extends from the bladder apex to the umbilicus and forms the median umbilical ligament. Urachal remnant is a rare congenital anomaly, with an incidence of 2:300,000 in infants and 1:5,000 in adults. Traditional surgical management of benign urachal disease involves the radical excision of all anomalous tissue with or without a cuff of bladder tissue via the open approach (76). Urachal carcinoma accounts for <0.5% to 2% of all bladder tumors and approximately 40% of vesical adenocarcinomas.

Patients with resectable tumors traditionally underwent en bloc cystoprostatectomy and wide excision of the urachus and umbilicus. Extended partial cystectomy and umbilectomy provide survival rates comparable to those of radical cystectomy (77). The surgical approach has leaned more toward bladder sparing because published reports have not shown an advantage compared to radical surgery (78).

Surgical Techniques

Urachal Adenocarcinoma

Patient preparation, positioning, and port placement are similar to those previously described for RARC (79,80). The peritoneal and preperitoneal tissue between the medial umbilical ligaments is dissected free of the transversalis fascia. The dissection must include an extensive resection of the peritoneum lateral to the two medial umbilical ligaments, which defined the lateral limits, the posterior sheath of the rectus muscle of the abdomen to the arcuate line and the muscle fibers of the rectus muscle below it, the extraperitoneal fat in the space of Retzius as the anterior limit, the urachus up to the umbilicus superiorly, and sparing the umbilical skin.

The bladder is distended with 200 mL normal saline to facilitate the mobilization and dissection. The junction of the solid tumor with the bladder is determined on the anterior aspect by inflating and deflating the bladder, and a cystotomy is made. The excision of the bladder dome is performed with a 2-cm margin of normal mucosa. The specimen is enclosed within the Endo Catch bag and placed in the right iliac fossa. The bladder is closed in two layers using absorbable sutures.

Bilateral extended pelvic lymphadenectomy is performed as described in the RARC section. The three specimens (the resected tumor and two lymphadenectomy specimens) are removed in separate bags through the supraumbilical port.

Urachal Remnants

The patient is placed in a supine position and a Foley catheter is inserted in the bladder. Three trocars are generally used: the 12-mm camera port is placed in the midline above the umbilicus and two 8-mm robotic trocars are placed on either side, lateral to the rectus muscle. There are several other possible trocar placements as well (81,82).

The medial umbilical ligaments are clipped and divided. The peritoneal and preperitoneal tissue between the medial umbilical ligaments is dissected free of the transversalis fascia. Dissection is carried along the preperitoneal plane toward the umbilicus, surrounding the cyst. The cephalic side of the lesion is ligated at the umbilicus and divided. The umbilicus is usually not excised. The bladder is filled via the urethral catheter and the cuff is removed. The specimen is placed in a laparoscopic bag and removed by the 12-mm port site. The bladder defect is closed using 4-0 and 3-0 running suture.

ROBOTIC BLADDER DIVERTICULECTOMY

A bladder diverticulum is a herniation of the bladder mucosa as a result of bladder outlet obstruction. Bladder diverticulectomy (BD) has been performed using several approaches, such as open, laparoscopic, or robotic (83–85). An endolaparoscopic approach combining laparoscopic diverticulectomy with transurethral resection of the prostate (TURP) provided decreased blood loss, postoperative analgesic requirement, and shorter hospitalization compared to open surgery (83–87). Limited reports exist as regard to robotic bladder diverticulectomy (RBD) with approximately 44 cases reported to date (86). We describe the surgical technique of transperitoneal extra- and transvesical RBD.

Surgical Technique

Patient’s position and ports placement are similar to RARC described earlier.

Extravesical Approach

Once the bladder is filled with saline, the peritoneum over the diverticulum is incised under direct visualization (0-degree lens). The diverticulum is dissected circumferentially to its neck using blunt and sharp dissection. A cystotomy is made at the neck of the diverticulum and the diverticulum is excised and is placed in an Endo Catch bag for later retrieval. The scope is then advanced toward the cystotomy and the bladder is surveyed to ensure no injuries to the ureteral orifices (UOs). The ureteral catheter is removed and the cystotomy is closed in two layers. A Jackson-Pratt drain is placed, the ports are removed, and the specimen is retrieved.

Transvesical Approach

This is the preferred approach for many BDs that are large or close to the UOs. Once the bladder is filled with saline, a midline cystotomy is performed. The cystotomy edges are laterally retracted using stay sutures. The UOs are identified and the neck of the diverticulum is scored. The Foley catheter tip is advanced into the diverticulum, the balloon is inflated, and the diverticulum is filled with saline. The diverticulum is dissected to its neck from outside the bladder. The bladder mucosa at the diverticulum neck is incised, and the diverticulectomy and bladder closure are carried out as described previously.

Concomitant Procedure

If a concomitant procedure is planned, a sequential approach is employed. For simultaneous robotic prostatectomy, an extravesical approach is used, and this is carried out first. For concomitant robotic simple prostatectomy (RSP), RBD is carried out first using a transvesical approach. This is followed by transvesical adenomectomy. The bladder is sutured at the end of the enucleation. For a concomitant TURP, the TURP is performed first, followed by RBD.

Postoperative and Follow-up

The patient is discharged with an indwelling 18Fr Foley catheter that is removed after cystogram on POD 7 to 8.

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SECTION III ■ PROSTATE

Section Editor: SANDIP M. PRASAD

CHAPTER 29 ■ ANATOMY OF THE PROSTATE

JONATHAN PAUL MANLEY, EDWARD W. ROWE, AND CHRISTIAN ANDREAS BACH

Precise knowledge of prostatic anatomy is a prerequisite for successful surgical intervention involving the prostate, be it radical prostatectomy, transurethral resection of prostate, brachytherapy, or prostatic biopsy. Our understanding of prostatic surgical anatomy has evolved over time by looking at pathologic specimens, transrectal ultrasound, multiparametric MRI images, and last but by no means least the advent of laparoscopy and robotic-assisted surgery, which benefits from increased magnification and illumination.

EMBRYOLOGY

The prostate develops from the distal urogenital sinus (the ventral portion of the cloaca) under the influence of testosterone from the fetal gonads. Epithelial outgrowths from the prostatic urethra bud into the surrounding mesenchyme from week 10 of embryologic growth. These buds subsequently signal back to overlying epithelial cells, inducing prostatic ductal formation. By week 12, there are five groups of tubules that progress to form the lobar anatomy of the prostate (1–3).

GROSS ANATOMY

The normal prostate is a fibromuscular and glandular organ located within the male pelvis. It resembles an inverted pyramid, is approximately 20 to 30 mL in volume, and is 4 cm in length by 4 cm at it widest point. Commonly, the prostate is described as having an apex, the inferior limit, and a base on which the bladder rests. Throughout its length run the urethra and ejaculatory ducts. Related structures include the rectum and Denonvilliers fascia that lie posterior to the prostate and the paired seminal vesicles and ampullae of the vasa deferentia that lie posterolateral to the prostate and posterior to the bladder (Fig. 29.1).

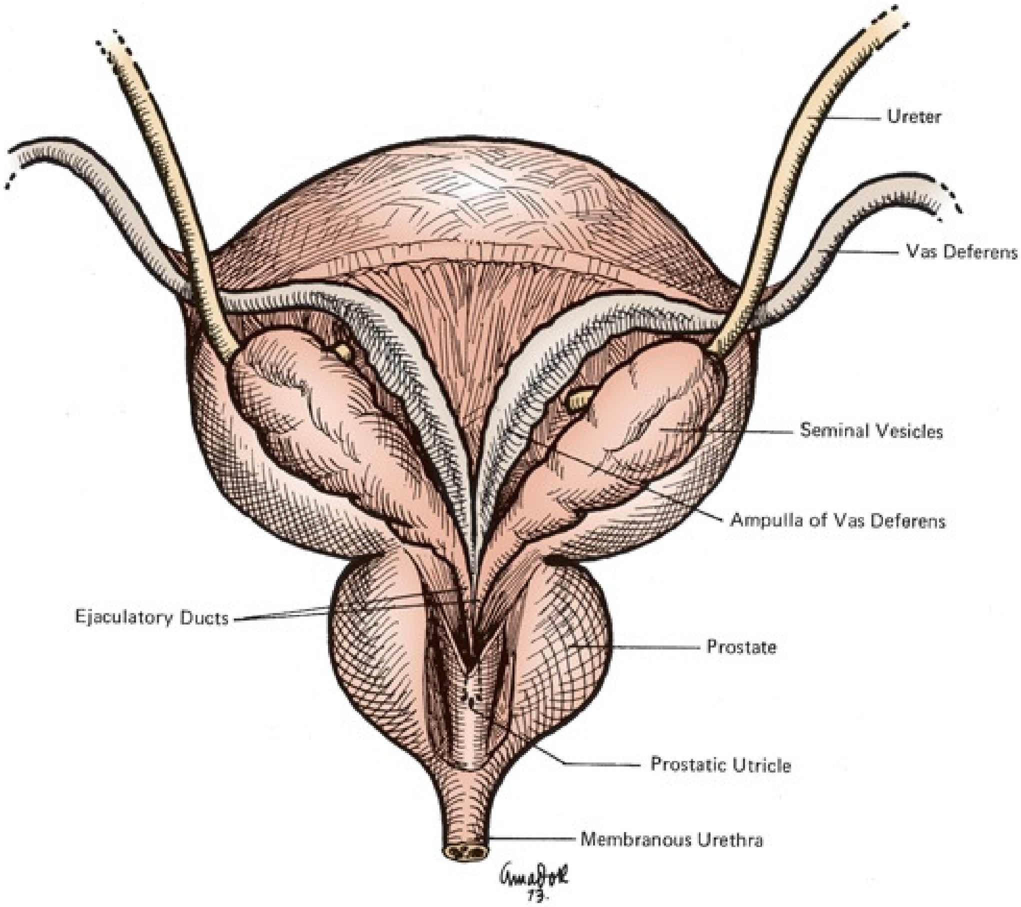

FIGURE 29.1 Relationship of the prostate and the seminal vesicles.

ZONAL ANATOMY

Historically, intraprostatic anatomy has been difficult to define. Previously, the prostate has been described as a lobar structure, most commonly with five lobes: two lateral, a median, a posterior, and an anterior lobe. The zonal intraprostatic anatomical structure proposed by McNeal (4), following microscopic examination of the prostate, is now widely accepted. The zones include the peripheral zone, transition zone, central zone, and periurethral zone and the anterior fibromuscular stroma (5). The peripheral zone is most posterior and is composed of long, branched glands from which the majority of carcinomas are thought to derive. The central zone consists of short glands from which prostatic hypertrophy is thought to arise (Fig. 29.2).

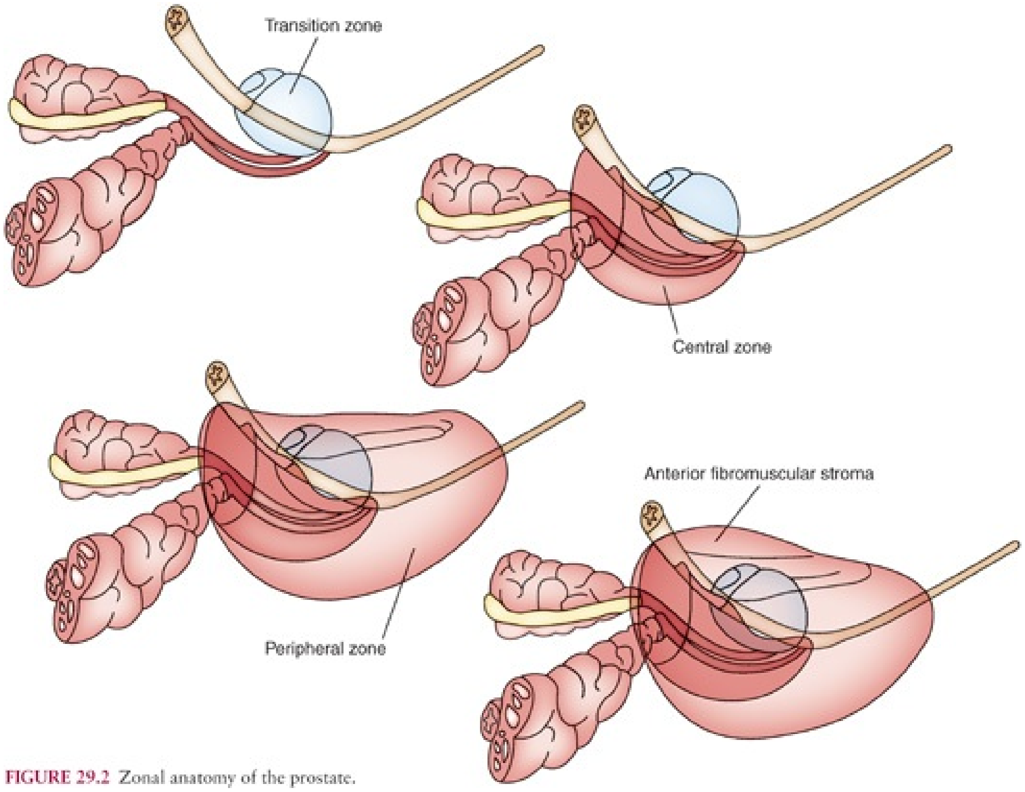

FIGURE 29.2 Zonal anatomy of the prostate.

The prostate is often described as having a “capsule”; however, it is not an anatomically discrete structure rather an aglandular fibromuscular layer contiguous and inseparable with the acini and parenchyma of the prostate. Surrounding this are the periprostatic fasciae, as described in the following section.

URETHRAL ANATOMY

The urethra traverses the prostate from bladder to prostatic apex (approximately 1 cm from the pelvic floor). The external sphincter may be visualized, on cystoscopy, as a ridge of urethral mucosa distal to the verumontanum. The verumontanum represents the terminal end of the ejaculatory ducts as they course through the prostate from seminal vesicles/vas deferens, and at this point, the urethra angles upward by approximately 45 degrees. The opening in the apex of the verumontanum is known as the prostatic utricle (a remnant of the müllerian duct) (6).

PELVIC FASCIAL ANATOMY

With recent advances in robotic pelvic surgery, we have gained a more comprehensive understanding of the pelvic fascia. Unfortunately, the nomenclature of pelvic fascia is not well standardized; to simplify things, the pelvic fascia may be divided into the parietal endopelvic fascia that primarily covers pelvic musculature and the visceral endopelvic fascia covering the pelvic organs.

The parietal endopelvic fascia covers the muscles of the pelvic wall and floor (piriformis, obturator internus, levator ani, and coccygeus) and joins the transversalis fascia and the periosteum of the hipbones. By fusing with the underlying visceral fascia, it forms a thickened structure; the arcus tendineus fascia pelvis (tendinous arch) stretching from the puboprostatic ligaments (PPLs) to the ischial spine (7,8). Ventrally, the proximal prostate is covered by muscle fibers originating from the bladder, forming a structure known as the “detrusor apron.” The prostate is stabilized and supported by the PPLs that form fibrous bands from the visceral endopelvic fascia to the posterior aspect of the pubic bone and anterior to the urethral sphincter. It is suggested that the PPLs play an important role in the suspensory system of the continence mechanism (9).

The visceral pelvic fascia invests the pelvic organs and neurovascular structures. It is attached anteriorly to the posterior surface of the pubis (forming the potential space—“the cave of Retzius”) and posteriorly to the ischial spine (7).

It may be subdivided into an anterior, lateral, and posterior (Denonvilliers) periprostatic fascia (8,10). The anterior periprostatic fascia covers the prostate, detrusor apron, and dorsal venous complex (DVC) fusing to the fibromuscular prostatic capsule at the anterior commissure (10). The lateral periprostatic fascia covers the lateral glandular prostate sweeping around to meet the posterior periprostatic fascia. The posterior periprostatic fascia separates the prostate from the rectum and forms an important barrier to the spread of malignancy. Medially, it fuses with the prostatic capsule; laterally, it is separated from the prostatic stroma by a thin adipose layer and the neurovascular bundles (NVBs) of Walsh.

A comprehensive understanding of periprostatic fascia in radical prostatectomy allows for decisions regarding the method of NVB resection (intra-, inter-, or extrafascial). It is suggested that the further from the prostate the resection (i.e., extrafascial dissection), the greater likelihood of a safe oncologic margin, however, the greater chance of erectile dysfunction (4,11) (Figs. 29.3 and 29.4).

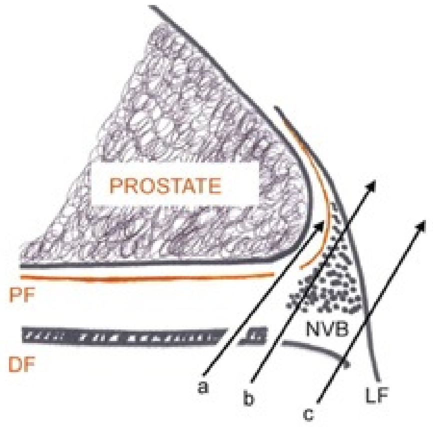

FIGURE 29.3 Axial view of the right posterolateral aspect of the prostate showing potential dissection planes. *a*, intrafascial plane; *b*, interfascial plane; *c*, extrafascial plane; *DF*, Denonvilliers fascia; *LF*, levator ani fascia; *NVB*, neurovascular bundle; *PF*, prostatic fascia. (From Martinez-Pireiro L. Prostatic fascial anatomy and positive surgical margins in laparoscopic radical prostatectomy. *Eur Urol* 2007;51[1]:598–600. Copyright © 2007 European Association of Urology. Published by Elsevier B.V. All rights reserved. Reprinted with permission of Elsevier.)

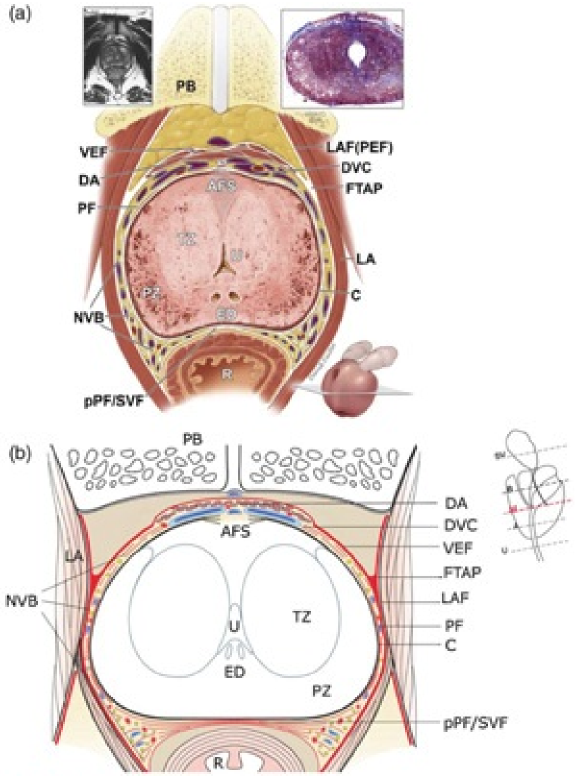

FIGURE 29.4 Axial section of the prostate and periprostatic fascia at midprostate level. **A:** Anatomic. **B:** Schematic. *AFS*, anterior fibromuscular stroma; *C*, capsule of prostate; *DA*, detrusor apron; *DVC*, dorsal vascular complex; *ED*, ejaculatory ducts; *FTAP*, fascial tendinous arch of pelvis; *LA*, levator ani muscle; *LAF*, levator ani fascia; *NVB*, neurovascular bundle; *PB*, pubic bone; *PEF*, parietal endopelvic fascia; *PF*, prostatic fascia; *pPF/SVF*, posterior prostatic fascia/seminal vesicles fascia (Denonvilliers fascia); *PZ*, peripheral zone; *R*, rectum; *TZ*, transition zone; *U*, urethra; *VEF*, visceral endopelvic fascia. (From Waltz J, Burnett A, Costello A, et al. A critical analysis of the current knowledge of surgical anatomy related to optimization of cancer control and preservation of continence an erection in candidates for radical prostatectomy. *Eur Urol* 2010;57:170–192. Copyright © 2010 European Association of Urology. Published by Elsevier B.V. All rights reserved. Reprinted with permission of Elsevier.)

VASCULAR AND NEUROLOGIC ANATOMY

The primary arterial supply of the prostate derives from the internal iliac arteries via the inferior vesical branch; however, other anatomic variants and accessory vessels include the internal pudendal, superior vesical, obturator, and middle rectal artery (12). It is suggested that accessory pudendal arteries may be present unilaterally or bilaterally in 4% to 75% of the population. If these aberrant vessels are the sole supply to the corpora cavernosum, then preservation during prostatectomy is required to preserve erectile function (13). The prostatic artery then divides into branches supplying the urethra, transition zone and periurethral glands (the arteries of Flocks), and those supplying the fibromuscular capsule (6).The capsular branches run alongside cavernous nerves to form the NVBs. Clear understanding of the NVB structure allows for “nerve-sparing” techniques improving functional outcomes postradical prostatectomy.

The pelvic plexus, located on the lateral wall of the rectum, contains sympathetic nerve fibers from the ganglia of T12–L2 responsible for emission as well as parasympathetic fibers originating from S2 to S4 that stimulate erection in the corpus cavernosum by causing vasodilatation. The majority of these nerve fibers travel laterally to the bladder neck and proximal prostate to coalesce as the NVB. The NVB runs distally within the periprostatic fascia toward the apex, where the NVB lie in the 2 and 10 o’clock positions, before piercing the pelvic floor to innervate the corpora cavernosa (8). Recent studies have shown that up to one-third of periprostatic nerve fibers run on the anterolateral aspect of the prostate, and as such, the “high release” and “veil of Aphrodite” robotic prostatectomy techniques are now used to preserve as many parasympathetic fibers and much erectile function as possible (14) (Figs. 29.5 and 29.6).

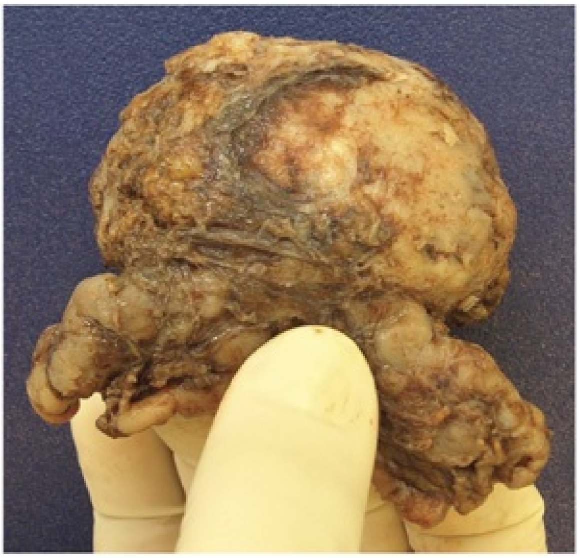

FIGURE 29.5 Prostatic specimen showing unilateral nerve spare. (Courtesy of Dr. John Oxley and Mr. Edward Rowe)

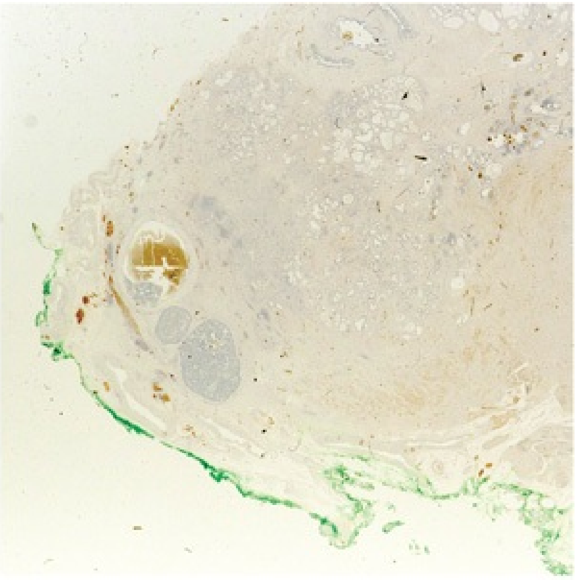

FIGURE 29.6 Prostatic histologic specimen stained for the neurovascular bundles. (Courtesy of Dr. John Oxley).

The prostatic venous drainage is by way of the DVC (Santorini plexus) to the internal iliac vein. The deep dorsal vein leaves the corpus cavernosus, travels under the pubic arch, and splits to form the superficial branch and two lateral branches. The superficial branch lies between the PPLs on the anterior surface of the prostate before piercing the fascia and joining the DVC. The lateral branches form plexuses that merge with the DVC around the bladder and rectum before draining via vesical and pudendal branches to the external iliac vein. An avascular plane is present at the prostatourethral junction between the prostate and DVC; this forms the landmark for DVC control during radical prostatectomy (15) (Figs. 29.7 to 29.9).

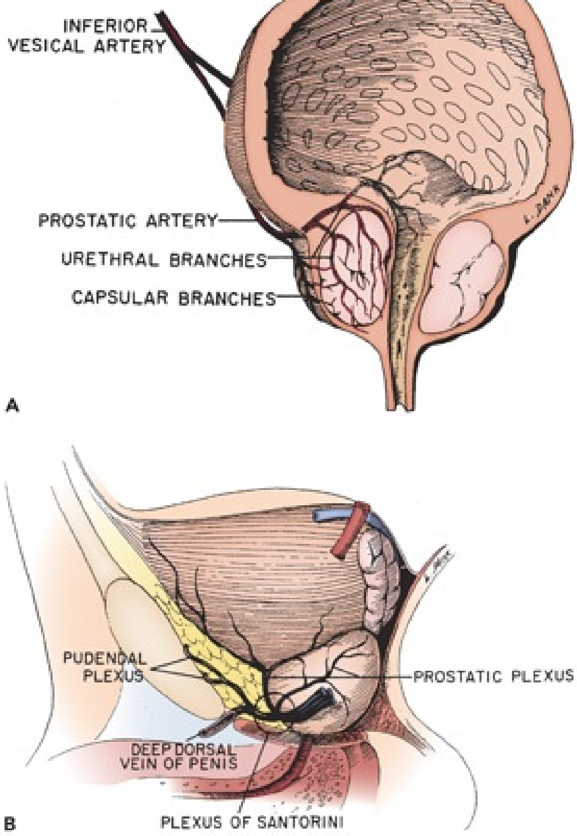

FIGURE 29.7 Vascular anatomy of the prostate. **A:** Arterial anatomy. **B:** Venous anatomy.

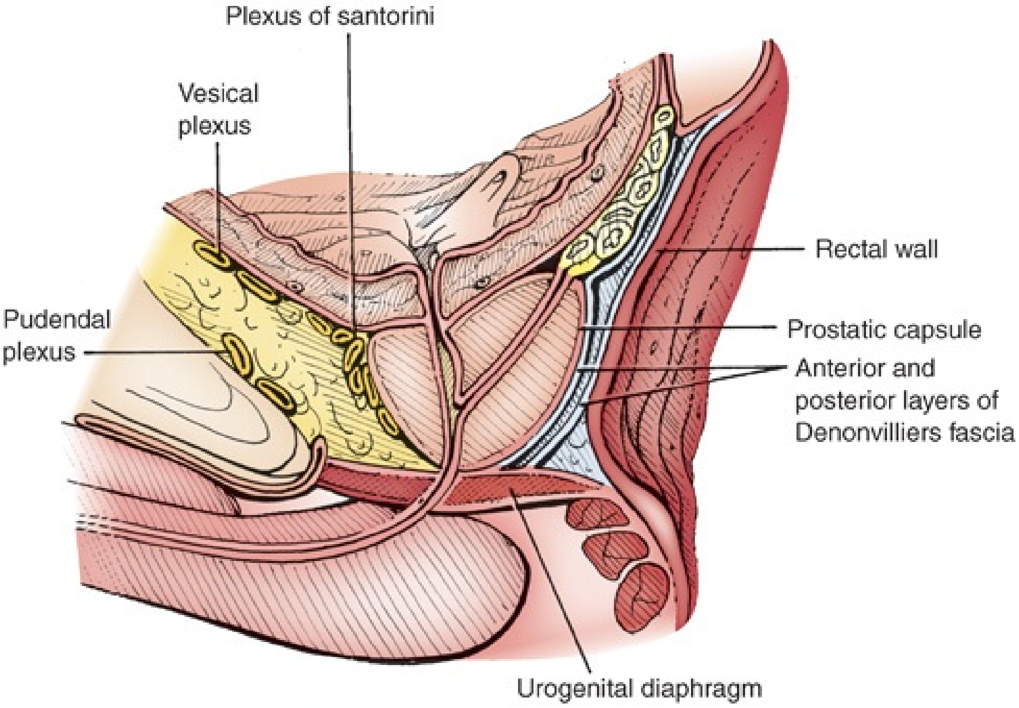

FIGURE 29.8 Relation of prostate to surrounding structures.

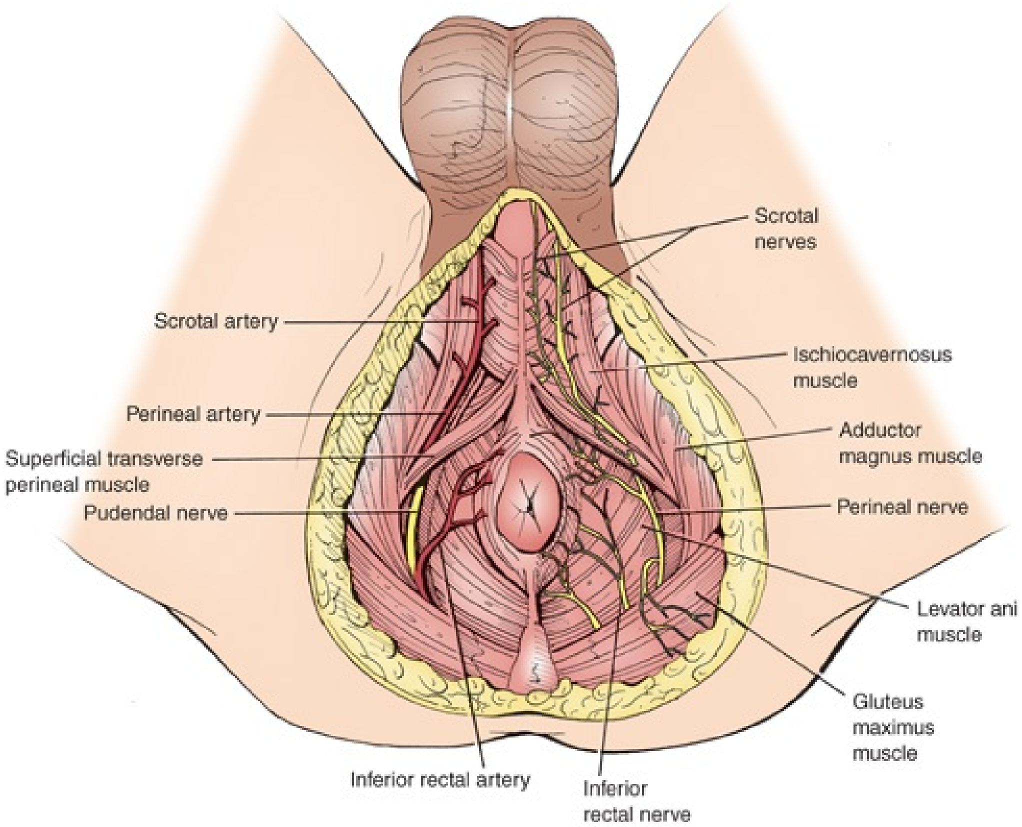

FIGURE 29.9 Pelvic nerves and musculature.

LYMPHATIC ANATOMY

The predominant lymphatic drainage is along the path of the prostatic artery to the obturator nodes. These nodes are located in a triangle bounded by the obturator nerve, the external iliac vein, and the femoral canal. Further drainage then occurs to the external iliac and common iliac nodes, with other potential metastatic sits including the external iliac and presacral nodes.

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CHAPTER 30 SURGERY FOR BENIGN PROSTATIC OBSTRUCTION

MUSAAB YASSIN, SANDIP M. PRASAD, AND HASHIM HASHIM

Benign prostatic hyperplasia (BPH) is a histologic diagnosis that refers to the proliferation of smooth muscle and epithelial cells within the prostatic transition zone. The precise etiology is unknown (1–3). Lower urinary tract symptoms (LUTS) secondary to benign prostatic enlargement are thought to result from bladder outlet obstruction (BOO) from the enlarged tissue (static component) and from increased smooth muscle tone and resistance within the enlarged gland (dynamic component). Both of these would results in LUTS secondary to benign prostatic obstruction (BPO). Obstructive voiding symptoms (e.g., hesitancy, slow stream, intermittent stream) have often been attributed to BPO. Overactive bladder symptoms (e.g., frequency, urgency, nocturia) secondary to detrusor overactivity (a urodynamic diagnosis) is thought to be a contributor to the storage symptoms seen in LUTS secondary to BPO (LUTS/BPO) (3).

It has been reported that among 50-year-old men the lifetime incidence of surgical or medical intervention for BPO may be as high as 35% (4). Wasson et al. (5) found that in a 3-year, multicenter, randomized controlled trial (RCT) comparing men with moderate LUTS/BPO treated by either watchful waiting or transurethral resection of the prostate (TURP), 24% of men in the watchful waiting arm eventually underwent surgical intervention.

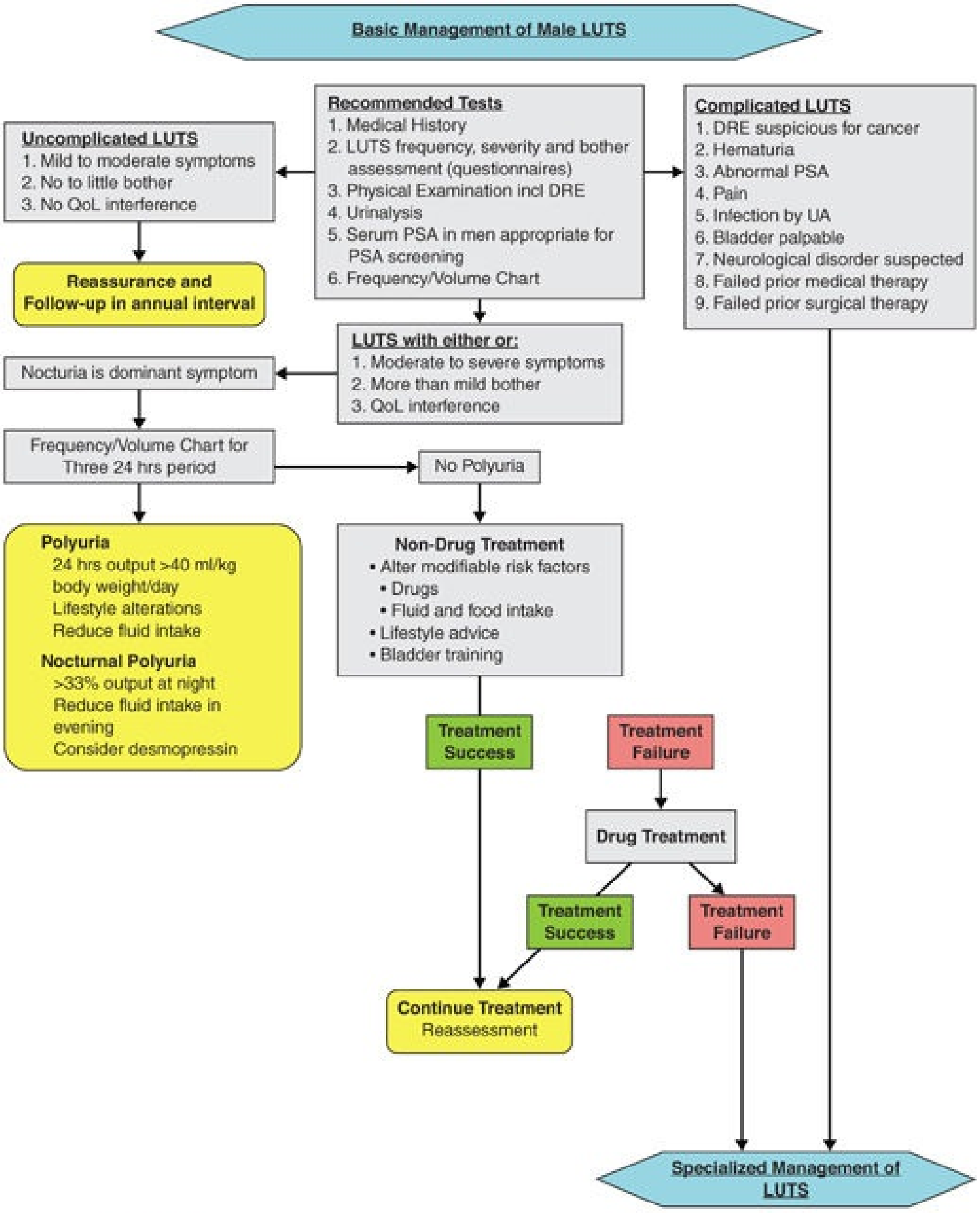
Although LUTS/BPO is not often a life-threatening condition, its impact on quality of life (QoL) can be significant and should not be underestimated (6). The most important motivations for seeking treatment were the severity and the degree of bother associated with the symptoms. These were also important considerations when assessing BPO and deciding when treatment is indicated (3).

It is necessary as health care professionals to be aware of the complex dynamics and interactions of the bladder, bladder neck, prostate, and urethra and their effect on patients’ symptoms (3). Recently, the treatment was more focused on the alteration of disease progression and prevention of complications that can be associated with LUTS/BPO in addition to the traditional approach of improving bothersome LUTS (7). A variety of conservative and pharmacologic treatments are employed including alpha-adrenergic antagonists (alpha-blockers), 5-alpha-reductase inhibitors (5-ARIs), anticholinergics, and phytotherapeutics (3) before surgical therapy is considered.

Surgical management of BPO has evolved significantly along with changes in medical management. A century ago, open prostatectomy was considered the standard surgical treatment of men with LUTS/BPO requiring removal of the adenoma. Subsequently, TURP was developed and became the first significant “minimally invasive surgical procedure.” More recently, a number of alternative surgical therapies have been introduced to treat men with BPO, most prominently laser-based therapies.

DIAGNOSIS

The American Urological Association (AUA) published their 2010 guidelines on the management of LUTS/BPO. A basic evaluation should be performed on every patient presenting to a health care provider with LUTS (Fig. 30.1 and Table 30.1). A validated questionnaire, such as the AUA Symptom Index or the International Prostate Symptom Score (IPSS), will better quantify the effect of patients' LUTS on their QoL.



Basic Management of Male LUTS
Recommended Tests
1. Medical History
2. LUTS frequency, severity and bother assessment (questionnaires)
3. Physical Examination incl DRE
4. Urinalysis
5. Serum PSA in men appropriate for PSA screening
6. Frequency/Volume Chart
Uncomplicated LUTS
1. Mild to moderate symptoms
2. No to little bother
3. No QoL interference
Reassurance and Follow-up in annual interval
Complicated LUTS
1. DRE suspicious for cancer
2. Hematuria
3. Abnormal PSA
4. Pain
5. Infection by UA
6. Bladder palpable
7. Neurological disorder suspected
8. Failed prior medical therapy
9. Failed prior surgical therapy
LUTS with either or:
1. Moderate to severe symptoms
2. More than mild bother
3. QoL interference
Nocturia is dominant symptom
Frequency/Volume Chart for Three 24 hrs period
No Polyuria
Polyuria
24 hrs output >40 ml/kg body weight/day
Lifestyle alterations
Reduce fluid intake
Nocturnal Polyuria
>33% output at night
Reduce fluid intake in evening
Consider desmopressin
Non-Drug Treatment
• Alter modifiable risk factors
• Drugs
• Fluid and food intake
• Lifestyle advice
• Bladder training
Treatment Success
Treatment Failure
Drug Treatment
Treatment Success
Treatment Failure
Continue Treatment
Reassessment
Specialized Management of LUTS

FIGURE 30.1 Basic management of lower urinary tract symptoms (*LUTS*) in men. The AUA guidelines on the management of LUTS/BPO in 2012 adopted the recommendations for diagnosis based on the 2005 International Consultation of Urologic Diseases and an article by Abrams et al. in 2009. *DRE*, digital rectal exam; *PSA*, prostate-specific antigen; *QoL*, quality of life; *UA*, urinalysis. (Adapted with permission from Chapple C, Abrams P. *Male Lower Urinary Tract Symptoms [LUTS]: An International Consultation on Male. Fukuoka, Japan, September 30 – October 4, 2013*. Montréal, Canada: Société Internationale d'Urologie and International Consultation on Urological Diseases, 2013.)

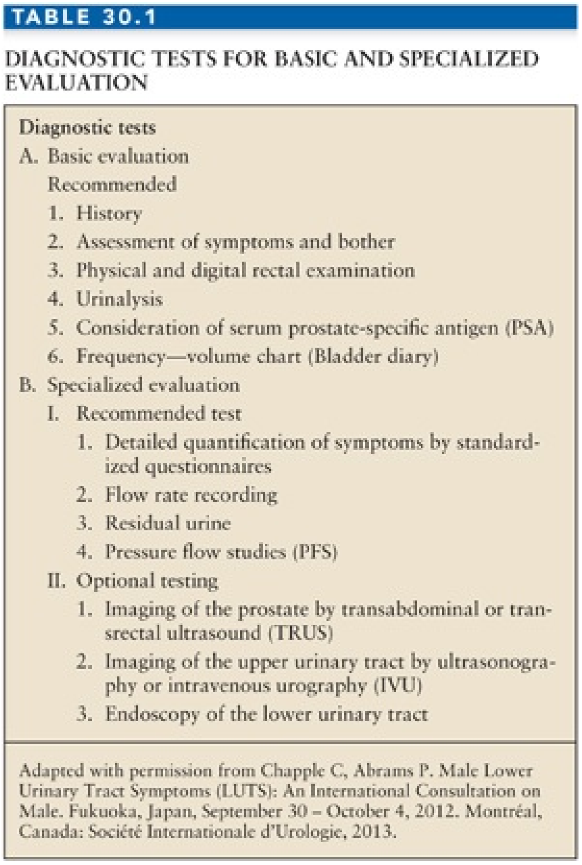


TABLE 30.1

DIAGNOSTIC TESTS FOR BASIC AND SPECIALIZED EVALUATION

Diagnostic tests

A. Basic evaluation
  Recommended
  1. History
  2. Assessment of symptoms and bother
  3. Physical and digital rectal examination
  4. Urinalysis
  5. Consideration of serum prostate-specific antigen (PSA)
  6. Frequency—volume chart (Bladder diary)

B. Specialized evaluation
  I. Recommended test
    1. Detailed quantification of symptoms by standardized questionnaires
    2. Flow rate recording
    3. Residual urine
    4. Pressure flow studies (PFS)
  II. Optional testing
    1. Imaging of the prostate by transabdominal or transrectal ultrasound (TRUS)
    2. Imaging of the upper urinary tract by ultrasonography or intravenous urography (IVU)
    3. Endoscopy of the lower urinary tract

Adapted with permission from Chapple C, Abrams P. Male Lower Urinary Tract Symptoms (LUTS): An International Consultation on Male. Fukuoka, Japan, September 30 – October 4, 2012. Montréal, Canada: Société Internationale d'Urologie, 2013.

CONSERVATIVE AND MEDICAL THERAPY

Following a thorough history, directed physical examination and assessment, conservative and medical therapy should be the initial treatments of choice. The medical treatment algorithms are described in Figures 30.2 and 30.3 (adopted from the European Association of Urology guidelines) but will not be discussed in this chapter.

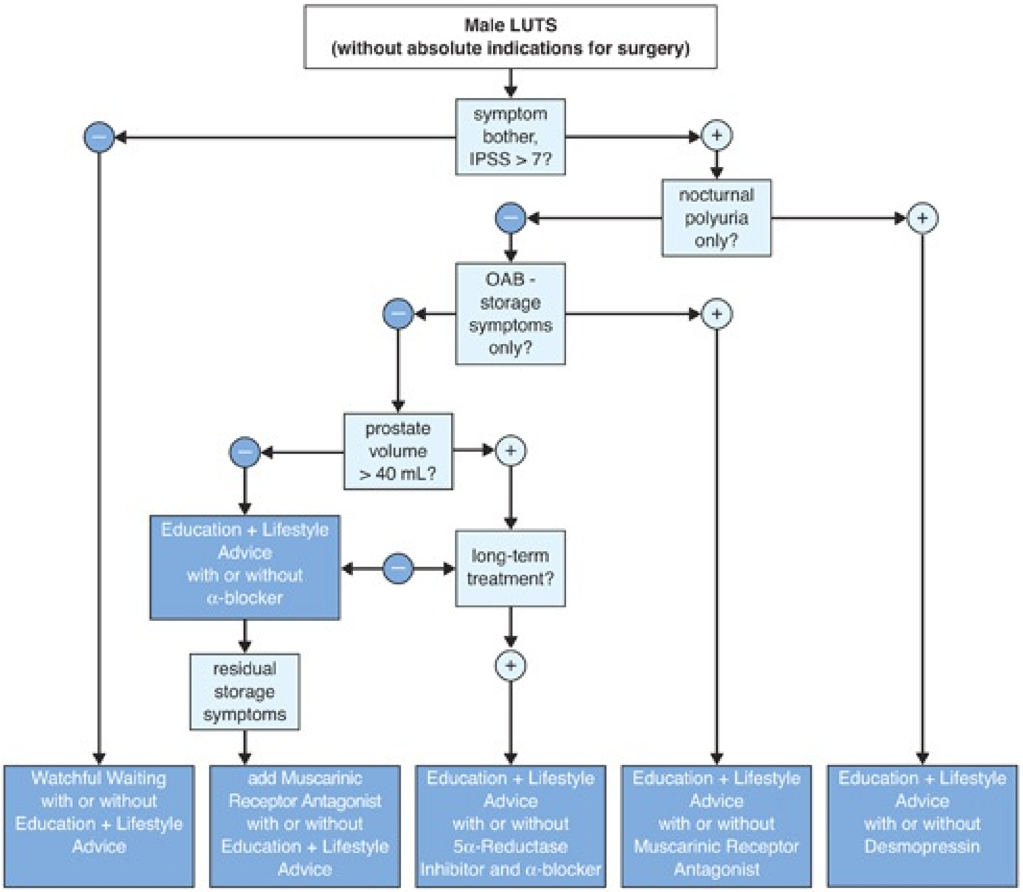

Male LUTS
(without absolute indications for surgery)
symptom bother, IPSS > 7?
−
+
nocturnal polyuria only?
OAB - storage symptoms only?
prostate volume > 40 mL?
Education + Lifestyle Advice with or without α-blocker
long-term treatment?
residual storage symptoms
Watchful Waiting with or without Education + Lifestyle Advice
add Muscarinic Receptor Antagonist with or without Education + Lifestyle Advice
Education + Lifestyle Advice with or without 5α-Reductase Inhibitor and α-blocker
Education + Lifestyle Advice with or without Muscarinic Receptor Antagonist
Education + Lifestyle Advice with or without Desmopressin

FIGURE 30.2 Treatment algorithm of male lower urinary tract symptoms (*LUTS*) using medical and/or conservative treatment options. Treatment decisions depend on results assessed during initial evaluation. Minus (−) indicate the absence and plus (+) the presence of the condition. *IPSS*, International Prostate Symptom Score; *OAB*, overactive bladder symptoms. (Reprinted with permission from Oelke M, Bachmann A, Descazeaud A, et al. EAU guidelines on the treatment and follow-up of non-neurogenic male lower urinary tract symptoms including benign prostatic obstruction. *Eur Urol* 2013;64[1]:118–140. Copyright © 2013 European Association of Urology. Published by Elsevier B.V. All rights reserved.)

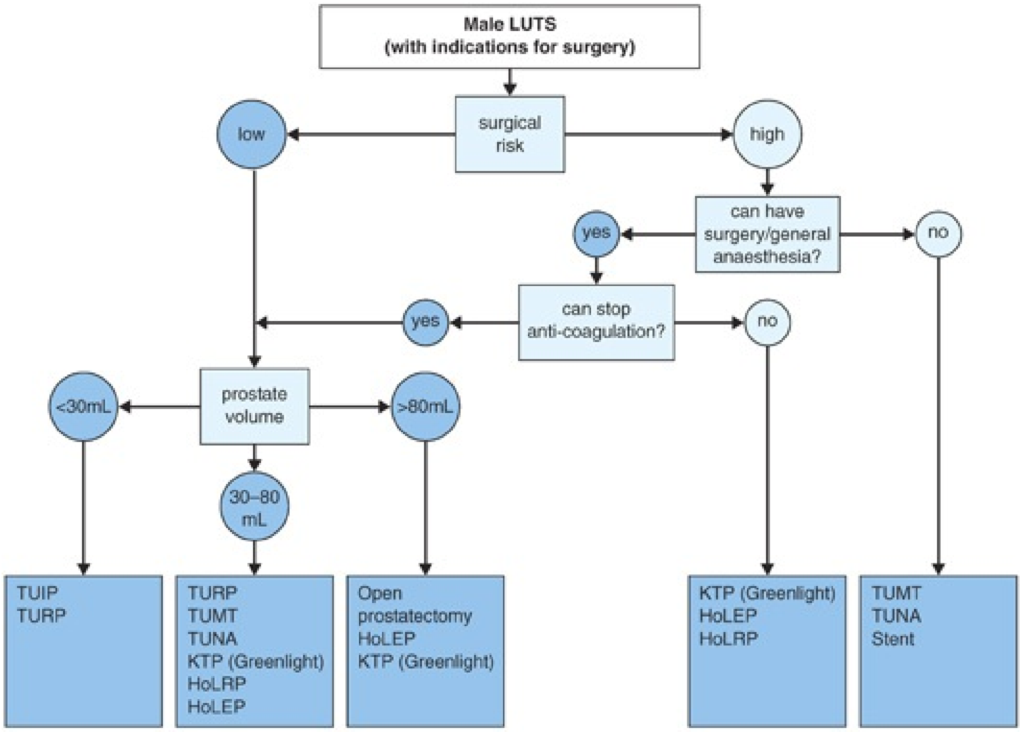


FIGURE 30.3 Treatment algorithm of bothersome lower urinary tract symptoms (*LUTS*) refractory to conservative/medical treatment or in cases of absolute operation indications. Note that this flowchart has been stratified by the patient's ability to have anesthesia, cardiovascular risk, and prostate size; however, the choice of the surgical techniques also depends on patients' preferences, willingness to accept surgery-associated side effects, availability of the armamentarium, and surgeon's experience with the operation technique. *HoLEP*, holmium laser enucleation of the prostate; *HoLRP*, holmium laser resection of the prostate; *KTP*, potassium titanyl phosphate; *TUIP*, transurethral incision of the prostate; *TUMT*, transurethral microwave thermotherapy; *TUNA*, transurethral needle ablation; *TURP*, transurethral resection of the prostate. (Reprinted with permission from Oelke M, Bachmann A, Descazeaud A, et al. EAU guidelines on the treatment and follow-up of non-neurogenic male lower urinary tract symptoms including benign prostatic obstruction. *Eur Urol* 2013;64[1]:118–140. Copyright © 2013 European Association of Urology. Published by Elsevier B.V. All rights reserved.)

INDICATIONS FOR SURGERY

There are certain absolute indications for surgical treatment of LUTS/BPO (Table 30.2). Typically, however, the management of patients depends on the degree of inconvenience they experience from their LUTS. The AUA clinical guidelines on LUTS/BPO recommend that men who experience nonbothersome symptoms of BPO should not be managed surgically. Patients with bothersome symptoms should undergo treatment, and the physician should review the benefits and risks of all approaches and interventions with the patient.

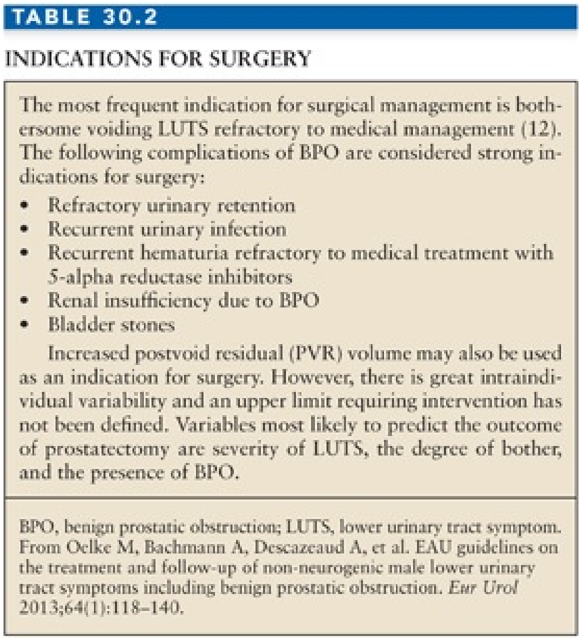


TABLE 30.2

INDICATIONS FOR SURGERY

The most frequent indication for surgical management is bothersome voiding LUTS refractory to medical management (12). The following complications of BPO are considered strong indications for surgery:

- Refractory urinary retention
- Recurrent urinary infection
- Recurrent hematuria refractory to medical treatment with 5-alpha reductase inhibitors
- Renal insufficiency due to BPO
- Bladder stones

Increased postvoid residual (PVR) volume may also be used as an indication for surgery. However, there is great intraindividual variability and an upper limit requiring intervention has not been defined. Variables most likely to predict the outcome of prostatectomy are severity of LUTS, the degree of bother, and the presence of BPO.

BPO, benign prostatic obstruction; LUTS, lower urinary tract symptom. From Oelke M, Bachmann A, Descazeaud A, et al. EAU guidelines on the treatment and follow-up of non-neurogenic male lower urinary tract symptoms including benign prostatic obstruction. *Eur Urol* 2013;64(1):118–140.

SURGICAL TECHNIQUES

There are several surgical techniques that can be considered for treating voiding LUTS/BPO. They can be divided into the following:

1. Minimally invasive therapy (MIT)
2. Endoscopic transurethral surgical treatments
3. Open surgical procedures
4. Laparoscopic or robot-assisted procedures
5. Investigational procedures

Minimally Invasive Therapy

MIT includes procedures that destroy or denature prostate tissue using a variety of energy sources, injected agents, or physical methods to draw open the prostatic urethra, that is, the procedures that do not lead to the physical removal of prostatic tissue. Laser prostate treatments are not included as they are generally used to remove tissue by ablation, resection, or enucleation (7).

The growing concern over the morbidity associated with treatment for BPO with TURP or open simple prostatectomy was a primary driving force behind the development of MIT approaches. These therapies typically are available for the treatment of patients with bothersome LUTS/BPO. Many of these minimally invasive treatments rely on the administration of high temperatures to produce coagulative necrosis of the prostate tissue. Ultimately, the goal of such hyperthermic treatment is to enlarge the prostatic fossa, similar to a surgical debulking but without the morbidity of surgery. However, these procedures are rarely done even in major North American and European centers.

Transurethral Microwave Thermotherapy

Transurethral microwave thermotherapy (TUMT) heats the prostate using a microwave antennae mounted on a urethral catheter and does not require cystoscopy except for initial measurement of prostatic length. This interventional therapy is effective in partially relieving the symptoms and bother believed secondary to BPO (3). The durability of TUMT treatment appears to have improved with the development of higher energy devices.

Practical Considerations. TUMT is likely more effective than medical therapy in reducing patients' LUTS, but it is likely less effective than surgical therapy. It is the least operator-dependent of the BPO interventions and predicting responders is difficult and inconsistent (3).

The view that these approaches lack sufficient durability of effect has resulted in a limited role of TUMT in the management of LUTS, despite potential advantages including outpatient capability, lack of sexual side effects, and avoidance of general anesthesia (3).

Transurethral Needle Ablation

Transurethral needle ablation (TUNA) affects prostate tissue by a thermal mechanism, with heat delivered via radiofrequency energy. Radiofrequency ablation (RFA) relies on the effects of passing electric current through tissue. This results in creation of lesions leading to coagulative necrosis. Initially, RFA was delivered as a monopolar technology in the form of TUNA of the prostate, but bipolar technology was subsequently developed (7).

A TUNA procedure involves cystoscopically placing two needles directly into the prostate by piercing the urethra and then administering radiofrequency energy that heats the prostate tissue to 100°C. As with microwave therapy devices, TUNA induces a coagulative necrosis effect. The efficacy of TUNA is comparable to that of microwave thermotherapy (8).

Practical Considerations. TUNA of the prostate is an appropriate and effective treatment alternative for bothersome moderate or severe LUTS/BPO (3). It is safe with low perioperative complications including bleeding. It has a low to nonexistent rate of sexual dysfunction and is attractive for that alone. Further surgical intervention is more likely to occur with TUNA compared with TURP, although the overall risk for morbidity clearly favors TUNA (3,7,9).

Endoscopic Transurethral Surgical Treatments

Electrosurgery

Transurethral Incision of the Prostate (TUIP) and Monopolar Transurethral Resection of the Prostate (M-TURP). The patient is placed in a dorsal lithotomy position, with the thighs abducted to allow manipulation of the resectoscope. After sterile preparation and draping is completed, the patient's anterior urethra is calibrated/dilated using Van Buren/Clutton sounds up to 30Fr. It is only necessary to calibrate the anterior urethra; excessive manipulation of the prostatic urethra may result in bleeding, which can make visualization difficult. Proper calibration is essential to reduce the theoretical risk of subsequent fossa navicularis or urethral stricture caused by the resectoscope manipulation, although some data suggest that the use of a urethral catheter postoperatively is the nidus for stricture (10). A 26Fr or 28Fr resectoscope is then inserted into the urethra. A 3% glycine or sorbitol solution is used for irrigation at gravity pressure. Cutting and coagulation currents should be adjusted to the appropriate levels for the electrical generator used for the case.

If the prostate volume is small (30 mL or less), the lateral lobes of the prostate are not coapting, there is no median lobe, and there is a high bladder neck, it may be appropriate to proceed with a transurethral incision of the prostate (TUIP), also known as bladder neck incision (BNI), especially in young, sexually active men (7). The bladder should be filled via the continuous-flow resectoscope, and with a TUIP-type electrocautery knife, incisions should be created and deepened until the capsule of the prostate is reached and extended just proximal to the verumontanum. The most popular unilateral incision is located at the 6 o'clock position, although the most commonly performed bilateral incisions are at the 5 and 7 o'clock positions (11).

If the prostate is more than 30 mL, or if there is a median lobe or the lateral lobes are coapting, a TURP is the more appropriate procedure to perform (Table 30.3). Monopolar transurethral resection of the prostate (M-TURP) is performed with an electrocautery loop and glycine or sorbitol irrigation. However, bipolar TURP devices have been developed that permit the resection of prostate tissue in a saline irrigant. If there is a median lobe present, resection should initially begin with this structure to allow the tissue resected later on from the later lobes to flow easily into the bladder. In a stepwise fashion, the median lobe is resected with the electrocautery loop. Resection of the median lobe is complete when bladder neck fibers are visualized. Particularly during the resection of the median lobe, care should be taken to not damage/involve the ureteral orifices in the resection.

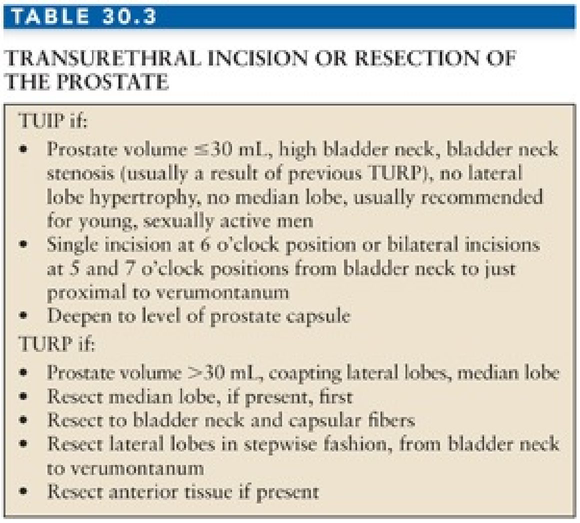


TABLE 30.3

TRANSURETHRAL INCISION OR RESECTION OF THE PROSTATE

TUIP if:

- Prostate volume ≤30 mL, high bladder neck, bladder neck stenosis (usually a result of previous TURP), no lateral lobe hypertrophy, no median lobe, usually recommended for young, sexually active men
- Single incision at 6 o'clock position or bilateral incisions at 5 and 7 o'clock positions from bladder neck to just proximal to verumontanum
- Deepen to level of prostate capsule

TURP if:

- Prostate volume >30 mL, coapting lateral lobes, median lobe
- Resect median lobe, if present, first
- Resect to bladder neck and capsular fibers
- Resect lateral lobes in stepwise fashion, from bladder neck to verumontanum
- Resect anterior tissue if present

Following complete resection of the median lobe of the prostate, attention can be turned to resection of the lateral lobes. There are several methods of doing this, and the surgeon should be comfortable in adapting his or her technique based on the anatomy of the prostate. The authors start resecting the left lobe starting at the 1 o'clock position, creating a trench, and proceeding from the bladder neck to a point just proximal to the verumontanum. This allows the adenoma to fall medially and downward and separates from the capsule. Resection should be carried down to the fibers of the bladder neck and prostatic capsule. The right lobe of the prostate can be resected in a similar fashion. The surgeon should take care not to resect too deeply and perforate the capsule as well as not to resect beyond (distal to) the verumontanum because that can damage the external urethral sphincter and cause stress urinary incontinence.

Following complete resection of the lateral lobes, the anterior tissue of the prostate should be inspected. If obstructing tissue is present at this location, it may be resected. The Ellik evacuator can then be used to remove the resected tissue fragments, which should be sent for pathologic analysis. The prostatic fossa should be reinspected because oftentimes open blood vessels are more apparent following Ellik evacuation and additional obstructive adenoma may appear that needs further resecting. Hemostasis should be ensured at the end of the procedure and all prostatic "chips" must be removed from the bladder. If it is difficult to establish hemostasis with the loop electrode, a rolling-ball electrode can be used. A three-way Foley catheter should be placed at the end of the procedure, and the authors use a 22Fr, three-way catheter with a 30-mL balloon. Continuous bladder irrigation with saline is generally necessary overnight; if bleeding persists, the Foley catheter may be placed on gentle and temporary traction.

Practical considerations. The choice between TURP and TUIP should be primarily based on prostate volume, with prostates 30 mL being mainly considered for TUIP and prostates of 30 to 80 mL for TURP. The advantages of TUIP are reduced bleeding incidents, shorter operation time, avoidance of transurethral resection (TUR) syndrome if using M-TURP, minimal and shorter postoperative bladder irrigation, lower risk of retrograde ejaculation, and shorter times for catheterization and hospitalization. The disadvantages are a higher rate of symptom recurrence and the need for additional surgery (3,11).

Urinary tract infections should be treated prior to TURP or TUIP. Three systematic reviews favored the use of antibiotic prophylaxis which would significantly reduce sepsis and the need for additional antibiotics after TURP. There was also a tendency toward higher efficacy in favor of short antibiotic courses compared to a single dose (11,13,14).

The ideal irrigant fluid for transurethral resection would be minimally conductive to avoid current dissipation from the electrode and to maximize the current at its point of contact with the tissues. Furthermore, the fluid has to be harmless when absorbed in the intravascular space. Such a fluid does not exist.

The types of irrigant fluids commonly used are the following (15):

- Normal saline (conducts electricity and therefore is not suitable for use with monopolar current): It is the irrigant of choice for diagnostic procedures (including cystoscopy) and for bladder irrigation postoperatively. It is suitable for use with laser resection/vaporization as well as bipolar TURP.
- Glycine (1.5%) (poor electrical conductor and hence is used for conventional M-TURP electrosurgery): It is relatively hypotonic but not cytolytic and carries a risk of dilutional hyponatremia. Glycine is an amino acid that inhibits neurotransmission in the retina, spinal cord, and midbrain.
- Water (poor conductor and can be used for M-TURP): It is hypotonic compared with plasma, and there is a risk of dilutional hyponatremia if it is used for prolonged periods of time. In addition, it is cytolytic that has the disadvantage of causing hemolysis if absorbed during TURP.
- Ethanol monitoring is a fairly new method of assessing fluid absorption during TURP. By using an irrigating fluid containing a trace amount of ethanol, a pocket-sized breathalyzer can measure the patient's end-expiratory ethanol concentration. Ethanol 1% is the standard strength, although ethanol 2% offers higher sensitivity and is suitable for research purposes (16,17).

Bipolar Transurethral Resection of the Prostate. Bipolar transurethral resection of the prostate (B-TURP) exploits a specialized resectoscope loop that incorporates both the active and return electrodes. This results in a dispersal of the current flow in the body, which theoretically reduces the deleterious effects of any stray current flow. The loop can be used to resect tissue as well as coagulate, vaporize, and transect tissue. Because 0.9% sodium chloride solution is used as an irrigation fluid, the risk of TUR syndrome is virtually eliminated (3).

Both postoperative catheterization and hospitalization times were shorter with B-TURP compared to M-TURP; this was thought to be due to reduced bleeding associated with improved coagulation abilities. Postoperative storage symptoms, particularly dysuria, were less common with B-TURP. However, most of these results were trends favoring B-TURP rather than statistically significant differences (18,19). TUR syndrome has not been reported with B-TURP due to the use of physiologic saline irrigation fluid and reduced fluid absorption during the procedure (11,18,20).

Practical considerations. Although the long-term treatment efficacy of M-TURP is widely accepted, the associated morbidity of M-TURP has led to the development of alternative therapy modalities. The choice of a monopolar or bipolar approach should be based on the patient's presentation, anatomy, the surgeon's experience, and discussion of the potential risks and benefits (3,7,11).

To date, five types of bipolar resection devices have been developed, which differ in the way in which bipolar current flow is delivered to achieve the plasmakinetic effect. These include the plasmakinetic system (Gyrus), transurethral resection in saline system (Olympus), Karl Storz, and Wolf. The devices plasmakinetic enucleation of the prostate or the "mushroom" technique has been described with the plasmakinetic bipolar system (Gyrus ACMI, Olympus Corporation, Tokyo, Japan) using 0.9% saline solution as an irrigation fluid. Essentially, mucosa at the apical adenoma is incised close to the verumontanum from the 5 o'clock to the 7 o'clock position. These grooves are deepened to the level of the surgical capsule. The distal middle lobe is dissected from the surgical capsule by the resectoscope sheath tip, and the surgical capsule is identified. Denuded supply vessels and hemorrhage spots on the capsule surface are identified and coagulated using the bipolar plasmakinetic loop to block the blood supply to the lobe. The right and left lobes are enucleated with the loop with arrest of bleeding. Finally, the bladder neck and enucleated lobes hanging at the bladder neck are resected (21,22).

Laser Surgery

An understanding of the wavelength or crystal used to produce laser energy during surgery of the prostate is critical when determining the type of laser vaporization to use. This is because tissue interaction caused by laser energy varies according to the wavelength, applied energy, fiber architecture, and tissue properties. This also means that the clinical results of different wavelengths are not comparable. Non-thermal effects, known as "ablation," also result in tissue destruction. Functional results will therefore differ in terms of perioperative handling of different laser devices, including learning curve, debulking tissue, durability of results, and type of complications (11).

Several types of new generation lasers for prostate surgery have emerged during the last decade, including the holmium:YAG, potassium titanyl phosphate:yttrium aluminum garnet (KTP:YAG), thulium:yttrium aluminium garnet (thulium:YAG), light blue optics:yttrium aluminium garnet (LBO:YAG), and the diode lasers. Energy can be transmitted through a bare, right-angle or interstitial fiber. Each laser has wavelength-specified energy–tissue interaction. Prostatic tissue destruction results from both thermal and nonthermal effects (11).

Holmium Laser Enucleation of the Prostate and Holmium Laser Resection of the Prostate. Extensive short- and long-term data suggest that holmium laser enucleation of the prostate (HoLEP) remains the modern gold standard alternative to TURP and open prostatectomy. The salutary benefits of the complete removal of the transition zone result in consistent outcomes (7).

As the wavelength of the Ho:YAG laser is strongly absorbed by water, the area of tissue coagulation and the resulting tissue necrosis is limited to 3 to 4 mm beyond contact, which is enough to obtain adequate hemostasis (2). Peak power produces non-thermal, localized tissue destruction, resulting in precise cutting of prostatic tissue (11).

The patient is positioned in dorsal lithotomy as for a TURP. Following dilation of the anterior urethra with sounds, a 26Fr or 28Fr resectoscope is inserted into the urethra. The 550-μm end-fire laser fiber is placed through the laser bridge or laser-stabilizing catheter. Normal saline irrigant is used during the procedure, and the resectoscope should be configured to continuous gravity flow.

The technique of HoLEP duplicates the complete adenectomy provided by open or minimally invasive simple prostatectomy. This technique involves identification and dissection in the surgical plane between the adenoma and surgical capsule, and this can be accomplished in a variety of ways. The prostate can be enucleated in a two-lobe or three-lobe technique depending on surgical anatomy and surgeon preference. Once the adenoma has been enucleated, the lobes are displaced into the bladder where a tissue morcellator is then used to retrieve the specimen (7).

If there is a significantly enlarged median lobe, it is often most expeditious to enucleate this structure first, as this maneuver will provide more room to accomplish the lateral lobe dissection (Table 30.4). To enucleate the median lobe, the holmium laser should be set at an energy of 2 J and a frequency of 50 Hz. Two sulci need to be generated at the 5 o’clock position and at the 7 o’clock position (Fig. 30.4). Beginning at the level of the bladder neck in the 5 o’clock position, a groove is cut with the laser along the sulcus from the bladder neck to a point proximal to the verumontanum (Fig. 30.5). This groove is deepened to the level of the surgical capsule. Once accomplished, the process should be repeated at the 7 o’clock position (Fig. 30.6). The final step in the enucleation of the median lobe can then be initiated at a point just proximal to the verumontanum. The laser fiber is moved in a transverse fashion between the apical extent of the 5 and 7 o’clock grooves. As the distal portion of the median lobe begins to separate away from the capsule, the beak of the resectoscope should be used as a leverage point to assist in lifting the median lobe upward. Once the dissection has reached the level of the bladder neck, the most proximal attachments of the median lobe can be divided and the entire median lobe pushed into the bladder.

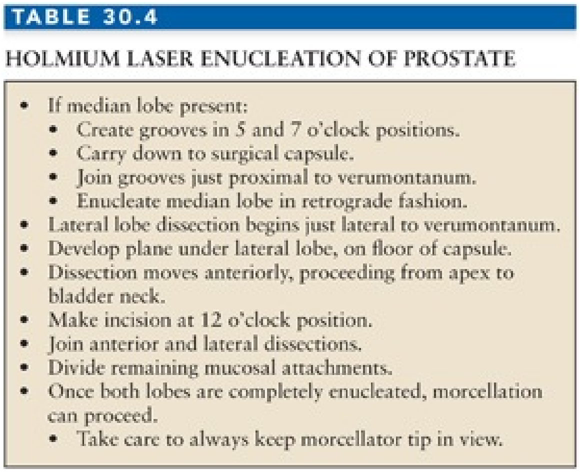


TABLE 30.4

HOLMIUM LASER ENUCLEATION OF PROSTATE

- If median lobe present:
  - Create grooves in 5 and 7 o’clock positions.
  - Carry down to surgical capsule.
  - Join grooves just proximal to verumontanum.
  - Enucleate median lobe in retrograde fashion.
- Lateral lobe dissection begins just lateral to verumontanum.
- Develop plane under lateral lobe, on floor of capsule.
- Dissection moves anteriorly, proceeding from apex to bladder neck.
- Make incision at 12 o’clock position.
- Join anterior and lateral dissections.
- Divide remaining mucosal attachments.
- Once both lobes are completely enucleated, morcellation can proceed.
  - Take care to always keep morcellator tip in view.

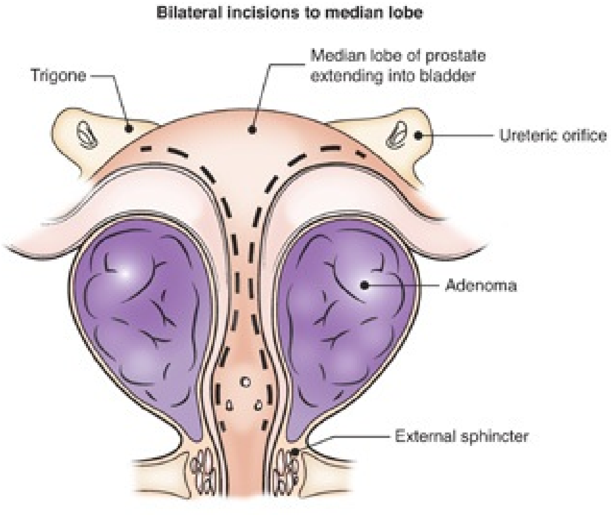

Bilateral incisions to median lobe
Trigone
Median lobe of prostate extending into bladder
Ureteric orifice
Adenoma
External sphincter

FIGURE 30.4 Cartoon representation of the architecture of the prostate and bladder neck. *Dashed lines represent the 5 and 7 o’clock grooves.*

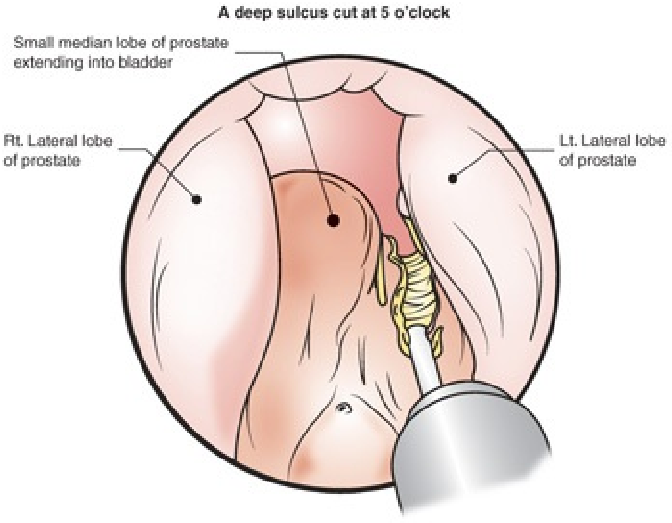

A deep sulcus cut at 5 o'clock
Small median lobe of prostate extending into bladder
Rt. Lateral lobe of prostate
Lt. Lateral lobe of prostate

FIGURE 30.5 The 5 o'clock incision is created with the end-fire holmium laser fiber.

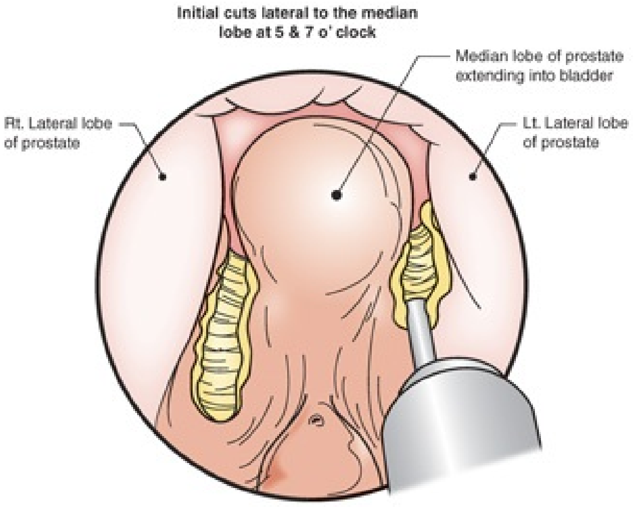

Initial cuts lateral to the median lobe at 5 & 7 o' clock
Median lobe of prostate extending into bladder
Rt. Lateral lobe of prostate
Lt. Lateral lobe of prostate

FIGURE 30.6 The 7 o'clock incision is subsequently developed, which isolates the median lobe.

If a median lobe was not present, an incision should be created at the 6 o'clock position, and this midline groove should extend from the bladder neck to a point just proximal to the verumontanum (Fig. 30.7).

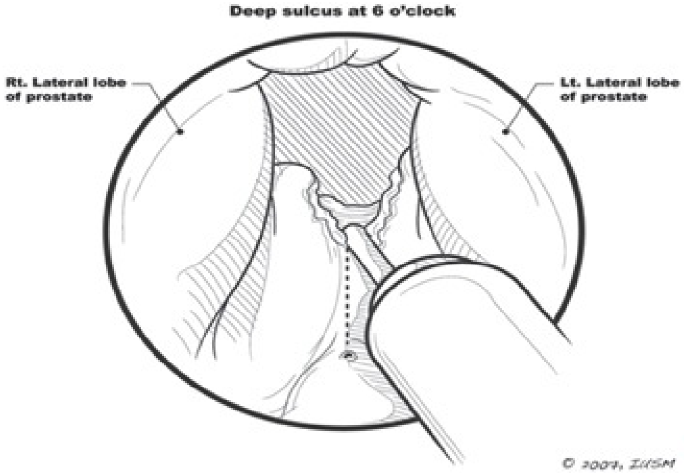


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FIGURE 30.7 When no median lobe is present, a groove (broken line) is created in the 6 o'clock position.

Dissection of the right lobe is initiated by incising the mucosa lateral to the verumontanum in a transverse fashion, thereby exposing the adenoma near the apex. Once the initial plane is developed under the right lobe, dissection should proceed proximally toward the bladder neck, freeing the lateral lobe from the capsular floor. At some point, it will become apparent that the lateral attachments of the lobe impede dissection. At this point, the surgeon should detach the lateral most aspect of the right lobe, near the apex. During the apical dissection, the laser frequency should be changed to 40 Hz to prevent thermal injury of the urinary sphincter. The dissection should be continued until difficulty is encountered with exposure of the plane proximally. Attention should then be turned to the 12 o'clock region of the prostatic fossa, where the midline groove between the lateral lobes is located. The laser frequency should be readjusted to 50 Hz. Beginning at the bladder neck and proceeding distally, a groove is cut along this anterior position and should span from the bladder neck to the level of the verumontanum. Once the groove is created, it is again widened and deepened to the level of the surgical capsule along its entire extent. The right lobe should then be enucleated from the anterior aspect of the capsule by angling the tip of the laser fiber between the adenoma and the capsule. Capsular definition is often much easier at the bladder neck, so dissection should begin at that point. It is crucial to identify the extent of the remaining lateral attachments near the apex of the lobe. Once the junction between the planes is defined, usually by a mucosal strip or bridge, it is cut by the laser to join the planes. Laser settings should be adjusted to 2 J and 20 Hz during division of this mucosal strip. At this point, the right lobe will be held only by attachments at the bladder neck level. By following this plane further laterally, any remaining attachments in this area can be freed. Finally, one should proceed under the lobe and finish dividing attachments at the floor of the capsule and the posterior bladder neck. The lobe can then be pushed into the bladder by leveraging upward with the beak of the resectoscope. With complete enucleation of the right lobe, attention should be turned to the left lobe, which is enucleated as previously described for the right lobe. Once all lobes have been dissected free and pushed into the bladder, the capsular surface is then inspected carefully, and any bleeding sites should be addressed by defocusing the laser (positioning the tip of the fiber 2 to 3 mm away from the surface). A dry fossa is essential before beginning morcellation to optimize visualization and minimize the risk of bladder injury. The final aspect is to remove the enucleated adenoma by morcellation. The inner sheath of the resectoscope, along with the laser fiber and stabilizing catheter, is removed, and the rigid offset nephroscope is then inserted into the outer resectoscope sheath. Under direct visualization, the tip of the morcellator is inserted into the bladder and guided beneath a portion of adenoma. Once a portion of adenoma is engaged by the morcellator, it is important to keep the tip of the morcellator anteriorly within the bladder and within the visual field at all times to avoid bladder injury (23). The bladder should be kept full with continuous irrigating fluid when morcellation is being performed to reduce the risk of the morcellator catching the bladder wall and damaging that.

Practical considerations. Resection is usually performed when the prostate is smaller than 80 mL, whereas enucleation is used for larger glands. The basic principle of the holmium laser resection of the prostate technique is retrograde resection of the prostate and fragmentation of resected tissue inside the bladder to allow its evacuation through the operating channel of the resectoscope (11). With experience, HoLEP now allows patients with a very large prostate who would traditionally be treated with open prostatectomy to be treated endoscopically (7,24).

In prostates >100 mL, HoLEP proved to be as effective as open prostatectomy for improving micturition, with equally low reoperation rates at 5-year follow-up (11,25). One advantage of HoLEP is that with experience, there is no practical size limitation for its application. Significant improvements in symptoms and flow rate regardless of the size of the prostate have been reported (26). Furthermore, the rate of blood transfusion, catheterization time, and hospital stay did not depend on prostate size (25). Dysuria was the most common perioperative complication with an incidence of approximately 10% (7,11,27).

HoLEP is a cost-effective approach due to the reduction in nursing costs to manage bladder irrigation and clot retention due to the reduced risk for bleeding following surgery (28). Furthermore, the laser fibers and morcellator blades used during HoLEP are reusable, eliminating the costly disposals associated with most other surgical techniques for the treatment of BPO (7). Finally, there is virtually no thermal effect on the tissue, making it ideally suited for histologic examination (7,19)

HoLEP has been demonstrated to safely treat patients taking anticoagulant medication and men with urinary retention (11,29). It is important to realize that the technique is not easy to learn as traditional TURP, and the National Institute for Health and Care Excellence in the United Kingdom have recommended that HoLEP be performed only in specialized centers or with mentorship arrangements in place (30).

Laser Ablation of the Prostate: Holmium and Potassium Titanyl Phosphate. Laser ablation of the prostate employs laser energy to vaporize prostate tissue through the generation of temperatures >100°C. There are two lasers that are commonly used to ablate the prostate: the KTP land the Ho:YAG laser.

The KTP laser, also called GreenLight laser, consists of a 532-nm laser system that employs a high-powered green light visible wavelength. The laser energy can be fully transmitted through aqueous irrigants into the cell, where it is absorbed by hemoglobin, which is then rapidly heated, leading to vaporization of prostate tissue. The short optical penetration that is associated with this wavelength confines its high-power laser energy to a superficial layer of prostatic tissue that is vaporized rapidly and hemostatically with only a 1- to 2-mm rim of coagulation. The thin coagulation zone arises as a result of the quasi-continuous emission characteristics of the 532-nm laser. Typically, continual irradiation of a single point causes heat to diffuse into deeper tissue layers, creating coagulation wherever there is enough convection thermal energy for protein denaturation but insufficient energy for vaporization. These selective characteristics led to the use of the 532-nm laser in prostatectomy being coined “photoselective vaporization of the prostate” (PVP) (7). The Ho:YAG laser is a 100-W system that generates laser energy at a wavelength of 2,120 nm (infrared range), which is absorbed primarily by water and results in an optical penetration depth of 0.4 mm (7).

The current clinical PVP system is a 180 W–capable, 532-nm LBO (lithium triborate)–based laser system with a feedback mechanism to control energy with a water cooled redesigned high-power fiber. These modifications increase the potential vaporization efficiency of this laser. Subsequent modifications include an added coagulation power mode due to the intermittent pulsing and continuous flow of a room temperature irrigant over the tip of the laser fiber (31). However, at 120 W or greater, the higher efficiency seems to be obtained at the expense of hemostasis. This increased power and efficiency highlights a concern that if there was a misfire within the bladder at settings such as 180 W, there could be damage done to the bladder and ureteral orifices with the risk of rapid and potentially unrecognized bladder perforation (7).

Despite the different inherent attributes of the two laser energy sources, the fundamental technique of laser ablation is the same for both laser types. One of the inherent limitations of all laser approaches is that laser energy will desiccate the prostate tissue, ultimately impairing the tissue ablation as the procedure proceeds. With smaller glands, this may not be a meaningful issue; however, with larger glands, tissue desiccation will impede the effectiveness of ablation.

A side-firing laser fiber is used, with a 26Fr or 28Fr continuous-flow resectoscope configured with a laser bridge. Saline is the irrigant of choice. The resectoscope is passed into the bladder, and the locations of the ureteral orifices and verumontanum are confirmed. Laser ablation is a near contact procedure, meaning that the laser fiber should be maintained 1 to 2 mm away from the prostate tissue. The aiming beam and the side markings of the fiber should be identified. If a median lobe is present, this structure should be addressed first. The laser fiber is placed in close approximation to the median lobe tissue, and a slow, sweeping, rotating lateral motion of the laser fiber is performed while activating the laser energy. The tissue should be vaporized in layers, with a sagittal motion of the fiber, taking care to not vaporize the trigone or ureteral orifices. If a median lobe is not present, the laser should be positioned at the bladder neck in the 7 o'clock position, and the tissue should be ablated with a lateral sweeping motion until the fibers of the bladder neck are visualized. A groove should then be extended from the bladder neck to a point just proximal to the verumontanum. The groove should be deepened until capsular fibers are seen. A similar groove should be created in the 5 o'clock position, and then the tissue between the grooves should be ablated.

Returning to the 5 o'clock position, the tissue from this location up to the 1 o'clock position should then be ablated with a slow, continuous sweeping motion. Again, the laser should be maintained near the tissue but not buried into the tissue. Once the lobe is ablated, the contralateral lobe from the 7 o'clock position to the 11 o'clock position should be ablated in the same fashion. Bleeding vessels, most commonly encountered at the 5 o'clock and 7 o'clock positions, can be coagulated by defocusing the laser 2 to 3 mm away from the tissue or by using a lower energy setting. Following ablation of the prostate tissue and assurance of hemostasis, a Foley catheter should be placed. In general, bleeding is not significant, and continuous bladder irrigation is not typically required.

Practical considerations. Holmium laser ablation of the prostate (HoLAP) is suitable for small-to-moderate–sized prostates, but it is not efficient for larger prostate glands; it also generates no tissue specimen for histopathologic analysis (7,32).

HoLAP is an easier technique to learn then HoLEP with a shorter learning curve, but the procedure is rather slow (7,32).

In an RCT, PVP was as effective and safe as TURP for BPO, in particular for prostate sizes <70 mL (33). PVP was associated with less blood loss, lower rates of transfusion, decreased rates of capsular perforation, a lower likelihood of TUR syndrome, and shorter catheterization time and hospital stay, but longer operative length and higher rates of reintervention (34). Adverse sexual outcomes were significantly higher following PVP in larger glands above 70 mL in volume (35).

Thulium Laser Transurethral Vaporesection of the Prostate. Thulium laser transurethral vaporesection of the prostate (ThuVARP) uses a thulium YAG fiber to deliver light of 2,000 nm wavelength in a continuous-wave fashion to vaporize and resect prostatic tissue. Although a thulium laser has the same absorption characteristics as a holmium laser in water and tissue, it has superior properties in soft tissue surgery because of its continuous-wave output. Due to the slightly shorter wavelength, the depth of penetration is decreased to 250 µm (36). Instead of the tearing action on tissue caused by the pulsed emission of Ho:YAG, the continuous-wave output of Tm:YAG allows smooth incision and vaporization of tissue with excellent hemostasis (36). ThuVARP is a technique that resects the prostate in TUR-like tissue "chips." Although Thu:YAG is similar to the Ho:YAG with regard to hemostasis, vaporization capacity is significantly increased by the continuous-wave emitting mode. Therefore, tissue ablation is not only achieved by resection but also by simultaneous vaporization (36).

The ThuVARP "tangerine" technique (37) is so named due to its similarity to peeling a tangerine.

1. Make an incision bilaterally from the bladder neck at 5 and 7 o'clock to the verumontanum.
2. Deepen the incisions to the capsule.
3. Join the incisions at 5 and 7 o'clock, cutting transversely at the level just proximal to the verumontanum to the surgical capsule at 80W power.
4. After step 3 is completed, remove the median lobe.
5. Make a transverse incision at 1 o'clock in a direction from the bladder neck to just proximal to the sphincter.
6. Resect the left lateral lobes in small 'chips' by cutting in a semi-circular crescent curved motion

until the left lobe is resected to capsule. Use 120W power.

7. Repeat the same procedure on the right side.
8. Take small “chips” in a curvilinear manner.

ThuVARP is a safe and acceptable alternative to TURP for the treatment of symptomatic BPO (36). The technique has been shown to have good intermediate-term results when compared to TURP (37–42), although long-term symptom improvement and QoL gains are less quantified. The National Institute for Health and Research Health Technology Assessment in the United Kingdom has funded a trial to compare ThuVARP to TURP. Currently available data suggests that the advantages of ThuVARP are reduced blood loss, shorter hospital stay, earlier return to normal activities, shorter duration of catheterization, improved visualization during resection, and reduced incidence of TUR syndrome (43).

Practical considerations. ThuVARP uses the same resectoscope as TURP except for the need of an end-firing laser and bridge. ThuVARP showed equivalent efficacy when compared to TURP in one RCT and one nonrandomized prospective controlled trial with small- and medium-volume glands. Thu:YAG-treated patients had shorter duration of catheterization and shorter hospitalization times. Severe adverse events were significantly lower for ThuVARP compared with TURP (primarily, intraoperative and postoperative bleeding) (36). Because ThuVARP can be performed as an outpatient procedure, it carries the benefits of decreased cost due to avoidance of inpatient admission and associated issues (e.g., nosocomial infections).

Although ThuVARP is the most promising of all available laser prostatectomy techniques due to its sharing the same surgical skill set as TURP, unlike holmium (HoLEP), which has a steep learning curve.

The available clinical and preclinical experimental data suggests that Thu:YAG can be used in patients on anticoagulative drugs, similar to Ho:YAG, which has lower coagulative properties due to the pulsed energy application mode (36). Unlike KTP, ThuVARP can also retrieve prostatic tissue for histology.

Open Surgery (Prostatectomy)

Open prostatectomy is the oldest surgical treatment modality for LUTS secondary to BPO. Obstructive prostatic adenomas are enucleated using the index finger, either from the inside of the bladder (suprapubic procedure) or through the anterior prostatic capsule (retropubic procedure).

Suprapubic Prostatectomy

The patient is placed in a supine position, and the lower abdomen and genitalia are prepared and draped into the surgical field. A Foley catheter is placed into the bladder urethrally and secured into position. The initial approach is through a low midline incision or Pfannenstiel incision, and the fascia should be opened from the umbilicus to the symphysis pubis. The space of Retzius is entered, perivesical fat identified, and a self-retaining retractor positioned. The bladder should be identified and cleaned of anterior perivesical fatty tissue. The bladder should be filled to capacity by gravity. Stay sutures should be positioned in the detrusor just to the left and right of the midline, and a vertical incision in the bladder should then be created with electrocautery.

After opening the bladder, the intravesical component of the prostate should be identified. The ureteral orifices should be located, and to facilitate identification as the procedure progresses, they may be cannulated with 5Fr feeding tubes. To begin the enucleation process, an incision in the posterior aspect of the intravesical component of the prostate is made with electrocautery (Fig. 30.8). Care should be taken to ensure that the incision is safely away from the ureteral orifices and trigonal region. The capsule should be sharply freed from the adenoma, and the surgeon's finger can then be used to develop the space between the adenoma and the capsule (Fig. 30.9). By moving the finger in a lateral arc, this plane is extended down to the apical aspect of the prostate. Once the adenoma is completely freed from its attachments by this blunt dissection technique, it may be removed from the surgical field (Fig. 30.10). The prostatic fascia should be packed with sponges and pressure held for 5 minutes to aid in hemostasis. Absorbable 2-0 sutures should be placed in a figure-of-eight fashion at the 5 and 7 o'clock positions to control any blood vessels, which are typically encountered at these locations (Fig. 30.11). A 22Fr Foley catheter with a 30-mL balloon should be placed transurethrally (Fig. 30.12).

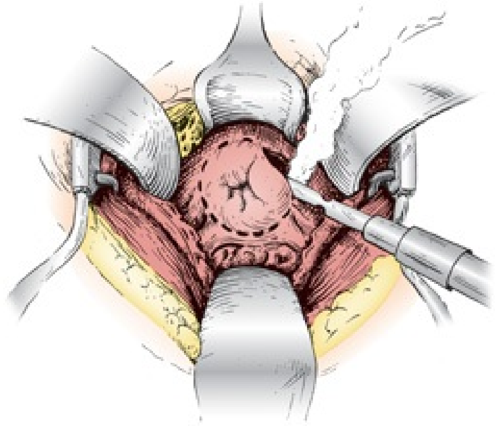

FIGURE 30.8 Incision of mucosa (dotted line) over the adenoma.

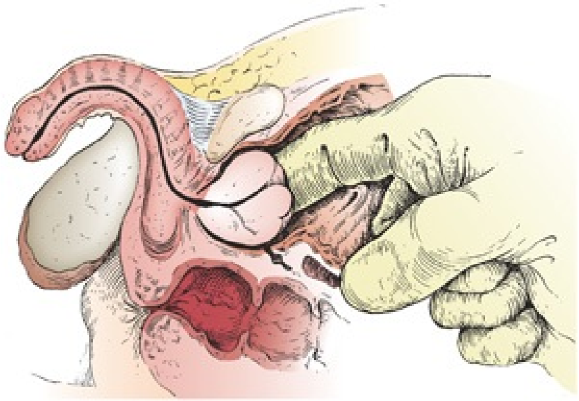

FIGURE 30.9 Digital enucleation of the adenoma.

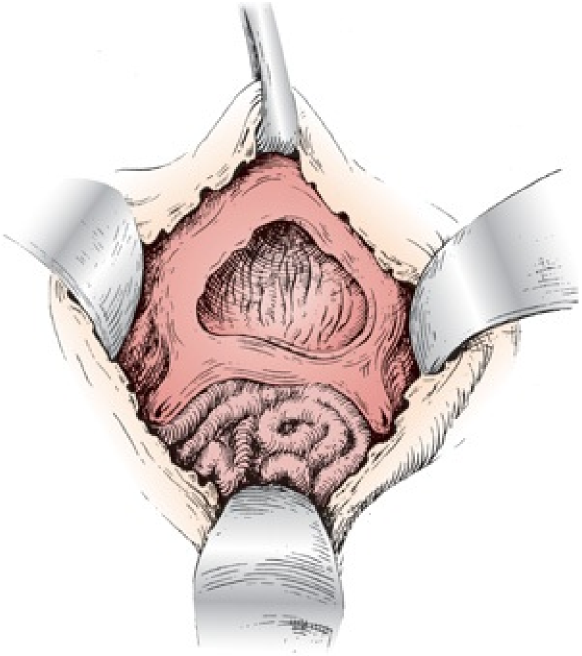

FIGURE 30.10 View of the empty prostatic fossa.

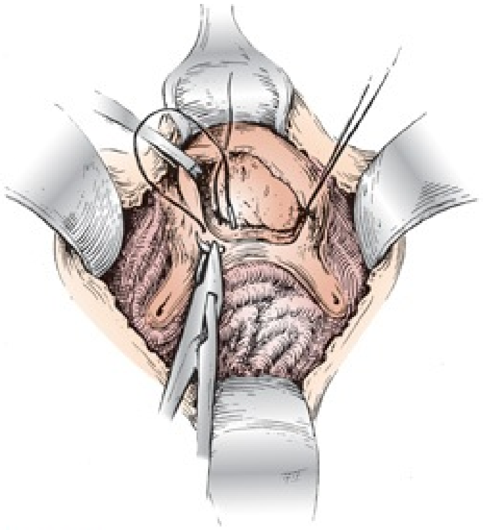

FIGURE 30.11 Hemostatic suture ligatures at the 5 o'clock and 7 o'clock positions.

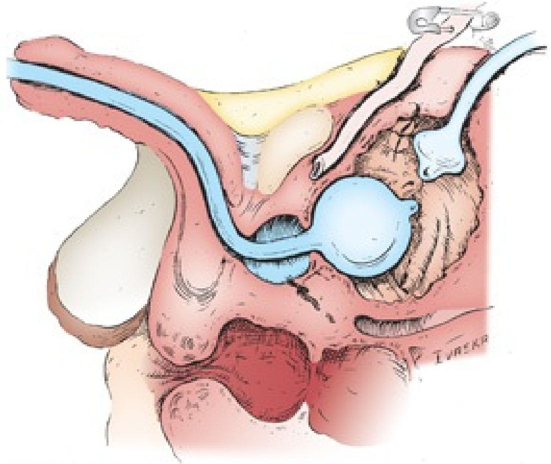

FIGURE 30.12 Foley catheter snug at the bladder neck: prevesical drain and suprapubic tube.

The bladder should be closed in two layers with running 3-0 and 2-0 absorbable suture. A suprapubic tube should be placed through the dome of the bladder, and the bladder subsequently closed around this tube in a purse-string fashion. A Penrose or Blake closed suction drain is then placed in the space of Retzius. The fascia is then reapproximated with the preferred fascial suture, and the skin is reapproximated with absorbable continuous suture or staples. The drains are sutured into place with 2-0 nylon suture. A continuous bladder setup using the suprapubic tube and the Foley catheter aids in maintaining patent drainage and minimizing blood clot formation.

Retropubic (Millin) Prostatectomy

The patient is placed in a supine position, and the lower abdomen and genitalia are prepared and draped into the surgical field. A Foley catheter is placed into the bladder trans-urethrally and secured into position. The initial approach is through a low midline incision, and the fascia should be opened from the umbilicus to the symphysis pubis. A Pfannenstiel incision can also be used. The retropubic space of Retzius is entered, perivesical fat identified, and a self-retaining retractor positioned. The fatty tissue overlying the bladder and prostatic capsule should be cleared.

At the midportion, on the outside of the prostatic capsule, 2-0 Vicryl sutures should be placed proximally and distally, to ligate the superficial blood vessels (Fig. 30.13). With electrocautery, an incision is created transversely between these two sutures (Fig. 30.14). A plane of dissection between the adenoma and the capsule should be bluntly created on either side of this incision (Fig. 30.15). The adenoma is progressively freed of its anterior, lateral, and posterior attachments with digital dissection. Following complete mobilization of the adenoma, its attachment to the membranous urethra can be sharply divided and the adenoma retrieved through the capsular incision; 2-0 Vicryl sutures should be placed in the 5 and 7 o’clock positions for hemostasis (Fig. 30.16). A 22Fr Foley catheter with a 30-mL balloon is placed, and the prostatic capsule is closed with 2-0 Vicryl sutures. A closed suction drain is placed in the space of Retzius; the fascia should be reapproximated with the surgeon’s preferred fascial closure suture, and the skin should be reapproximated with a continuous dissolvable subcutaneous suture or staples.

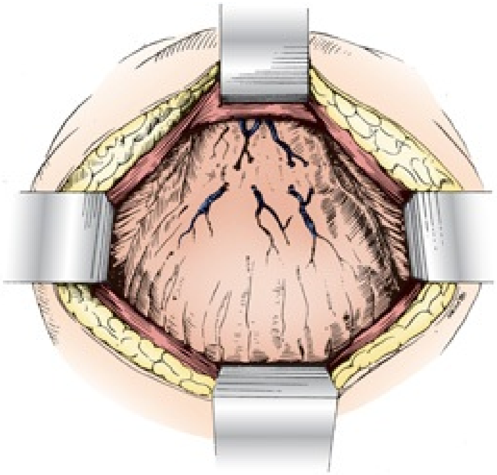

FIGURE 30.13 Ligation and division of periprostatic veins over the prostatic capsule anteriorly.

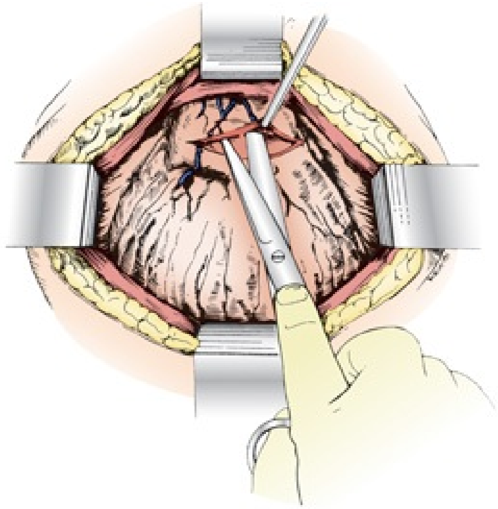

FIGURE 30.14 Transfixion sutures placed on the capsule anteriorly with an incision made transversely in the prostatic capsule.

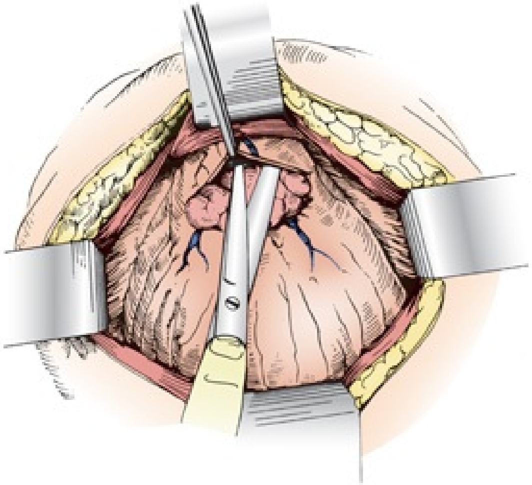

FIGURE 30.15 Continuing the dissection of the prostate of the adenoma from the prostatic capsule using Metzenbaum.

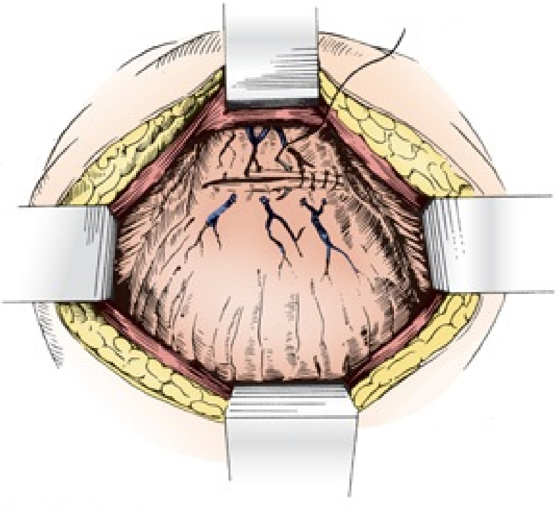

FIGURE 30.16 Closure of the incision of the prostate capsule anteriorly with interrupted Vicryl sutures.

Practical Considerations. Open prostatectomy is an effective treatment alternative for men with moderate to severe LUTS who are significantly bothered by these symptoms secondary to BPO. The choice of approach should be based on the patient's individual presentation including anatomy, the surgeon's experience, and discussion of the potential benefit and risks for complications (3).

Current indications for open prostatectomy include large prostates for which the surgeon does not feel comfortable performing TURP and for which other techniques such as HoLEP are not available. The presence of coexisting conditions such as large bladder stones, inguinal hernias, and large bladder diverticula may dictate an open surgical approach (7).

Open prostatectomy is the treatment of choice for large glands (>100 mL). There is usually a longer hospital stay and a larger loss of blood associated with open procedures compared with minimally invasive or cystoscopic approaches (3). It is the most invasive, but also the most effective and durable, procedure for the treatment of LUTS/BPO. Only HoLEP delivers similar results and with less morbidity (44–46). In the absence of an endourologic armamentarium and a Holmium laser, open prostatectomy appears to be the treatment of choice for men with prostates greater than 100 mL and drug treatment–resistant LUTS/BPO (11). An alternative in big glands is to use a larger resectope and only resect one side of the gland with bipolar TURP, then assess the patient's symptoms. If still bothered then the other lobe can be resected at a later stage. In other words, offer a staged TURP procedure.

Total prostate-specific antigen (PSA) levels <1 ng/mL have been described following open prostatectomy, suggesting that the largest part of the preoperative PSA level is associated with the adenomatous tissue, with very little contribution of the peripheral zone of the prostate (7,47).

Laparoscopic or Robot-Assisted Procedures

With the adoption of robotic assistance in the management of prostate cancer through robot-assisted laparoscopic radical prostatectomy (RALP) in the past decade worldwide, the use of minimally invasive technologies in the management of large glands as an alternative to open prostatectomy or complex/multiple transurethral procedures. The first laparoscopic simple prostatectomy was performed in 2002 (48), and initial series demonstrated increased operative times but shorter hospital stay and time of catheterization (49) compared with open simple prostatectomy. A large multi-institutional series of minimally invasive simple prostatectomy in over 1,300 patients from 23 institutions demonstrated low transfusion rates (3.5%), intraoperative complications rates (2%), and conversion rates (3%) with significant 12-month improvements in IPSS (50).

Robot-Assisted Laparoscopic Simple Prostatectomy

In 2008, Sotelo and colleagues (51) demonstrated the feasibility of RALSP, and subsequent studies have demonstrated similar improvements in voiding compared with open simple prostatectomy but with longer operative time and shorter length of stay and decreased blood loss (50). The technique is still in evolution, and can be performed through a transperitoneal or extraperitoneal approach. One of the main limiting factors is cost-effectiveness. Below are the steps of performing the procedure.

1. The patient is placed in dorsal lithotomy position with all pressure points padded and supported. The patient is secured to the table and then prepped and draped. A 20Fr Foley catheter is placed sterilely on the field.
2. Access to the abdomen is obtained through Veress needle or Hassan technique (surgeon preference), and the abdomen is insufflated to a pressure of 15 mm Hg.
3. Port placement is similar to RALP, with a 12-mm camera port placed just above the umbilicus, three 8-mm robotic ports, and a 12-mm and 5-mm assistant ports (see Chapter 33).
4. Similar to RALP, the bladder is released by anterior incision of the peritoneum to expose the space of Retzius. A combination of sharp and blunt dissection is performed to expose the prostate.
5. Defatting of the prostate and prostatovesical junction is performed to visualize the bladder neck. Typically, the endopelvic fascia does not need to be opened, and the dorsal vein complex may be left intact, but some authors do advocate for these steps.

6. Once the bladder neck is identified, the anterior bladder neck is divided and the Foley catheter is removed.
7. Stay sutures may be placed into the median lobe for anterior retraction or the fourth arm may be used to retract the adenoma superiorly. In patients with bladder stones, the bladder neck incision is often widened to extract these successfully.
8. The initial incision is made at the junction between the adenoma and the bladder neck posteriorly, taking care to identify the adenoma enucleation plane within the prostatic capsule. This plane is taken laterally and apically with a combination of sharp and blunt dissection; if this dissection is performed in the correct plane close to adenoma, this step typically has little bleeding. Dissection is carried out in anterior, posterior, and lateral planes until the distal urethra is encountered.
9. The Foley catheter is replaced and the distal urethra is divided circumferentially sharply at the apex. The specimen is removed and placed into a laparoscopic specimen extraction bag.
10. Hemostasis can be achieved using monopolar and bipolar energy along with selective suture ligation of the prostatic pedicles if needed.
11. The mucosa of the bladder is advanced to the posterior urethra using a 3-0 Monocryl suture; this step may be useful in hemostasis and is similar to the Rocco stitch used in RALP in regard to technique.
12. The cystotomy is closed in two layer using 2-0 Vicryl suture, and a 20Fr two-way catheter is placed with 30 mL in the balloon. A Jackson-Pratt drain is placed in the retropubic space.
13. Specimen retrieval and port closure are performed in the standard fashion as following RALP (see Chapter 33).

RALSP can also be performed using a transvesical technique wherein the bladder is left suspended in its native anatomic orientation and a large transverse cystotomy is made directly into the dome of the bladder. This is an excellent approach when bladder stones are present and the remainder of the enucleation follows the approach discussed earlier with the camera and surgical instruments operating through the cystotomy, which is closed at the end of the procedure.

Investigational Surgical Procedures

Prostatic Urethral Lift

This new treatment involves drawing the prostatic urethra open using endoscopically implanted prostheses using a specially designed delivery system (52–55). The prosthesis is made of two metallic tabs connected by nonabsorbable suture material. One tab is positioned on the capsular side of the prostate and the other on the urethral surface, and the suture is placed under tension, thereby creating a compressing effect between the two tabs (Figs. 30.17 to 30.19). Usually, between two and four of these prostheses are placed on each prostatic lobe, and the procedure can be performed under local anesthesia with or without sedation in an ambulatory setting.

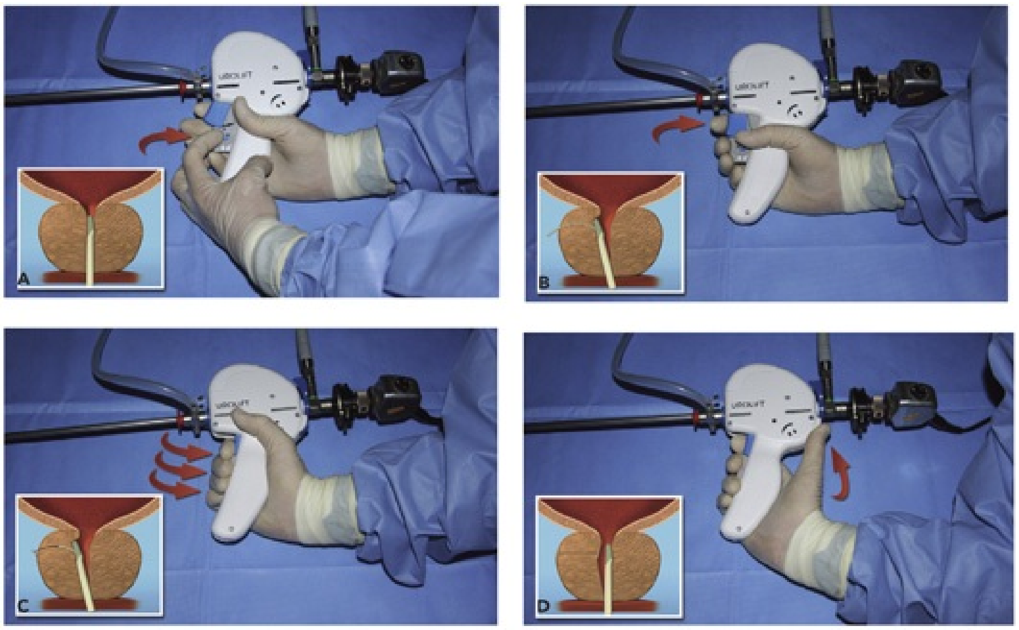

FIGURE 30.17 UroLift system delivery steps: (**A**) Release safety lock (red arrow); (**B**) deploy needle (red arrow); (**C**) retract needle, delivering capsular tab and tensioning monofilament (red arrow); and (**D**) attach urethral end piece and trim monofilament (red arrow). (Reprinted with permission from McNicholas TA, Woo HH, Chin PT, et al. Minimally invasive prostatic urethral lift: surgical technique and multinational experience. *Eur Urol* 2013;64(2):292–299. Copyright © 2013 European Association of Urology. Published by Elsevier B.V. All rights reserved.)

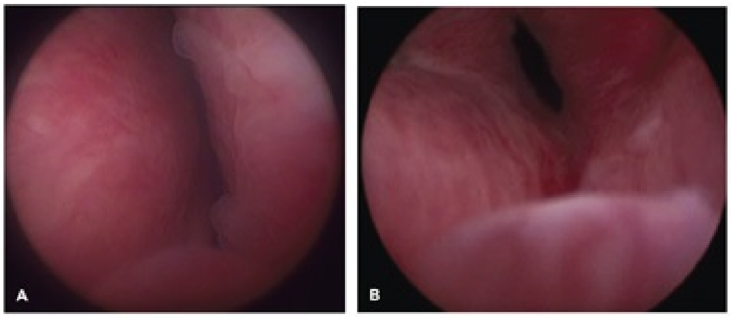

FIGURE 30.18 Endoscopic view of a tensioned internal tab invaginating (**A** to **B**) the prostatic urethra. (Reprinted with permission from McNicholas TA, Woo HH, Chin PT, et al. Minimally invasive prostatic urethral lift: surgical technique and multinational experience. *Eur Urol* 2013;64(2):292–299. Copyright © 2013 European Association of Urology. Published by Elsevier B.V. All rights reserved.)

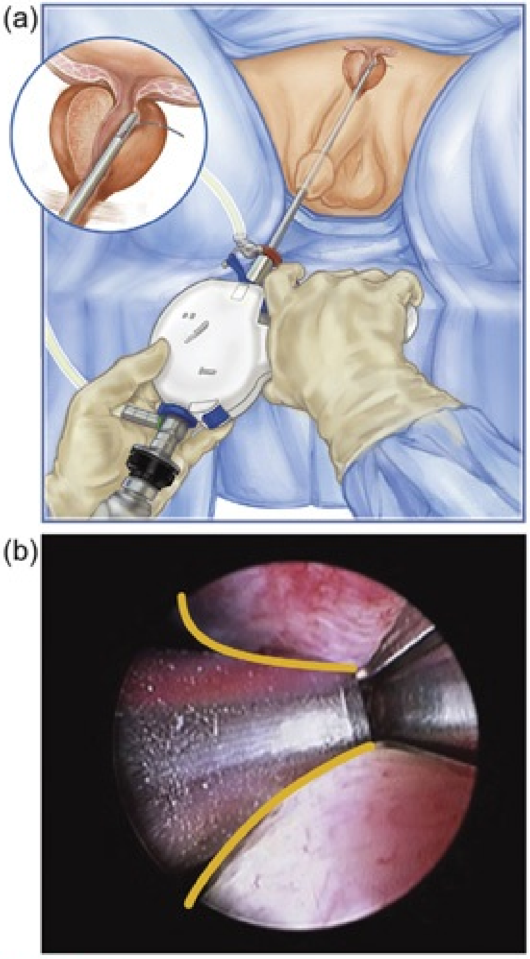

FIGURE 30.19 Deployment of distal UroLift implant. Surgical (a) and internal (b) view of implant deployment distal to initial implant. The tip of the device is angled 20 degree anterolaterally. Deployment is just proximal (above) to the verumontanum. (Reprinted with permission from McNicholas TA, Woo HH, Chin PT, et al. Minimally invasive prostatic urethral lift: surgical technique and multinational experience. *Eur Urol* 2013;64(2):292–299. Copyright © 2013 European Association of Urology. Published by Elsevier B.V. All rights reserved.)

Contraindications (56)

1. The presence of a median lobe, as the prostatic urethral lift (PUL) is designed for lateral lobe obstruction only; for the same reason, patients with bladder neck obstruction are excluded.
2. PSA >10 ng per mL, a level which warrants a mandatory histologic examination.
3. History of urinary retention, decompensated detrusor, or compromised renal function, as these conditions make the tissue removal mandatory.
4. Concomitant urinary infection due to the risk of a colonization of the foreign body.

Practical considerations. Prostate size is important in patient selection for PUL. Although some data suggest that very large glands may be successfully treated with PUL, we recommend excluding patients with a prostate volume >50 mL, especially during the learning curve phase (55,56).

Preoperative evaluation of patients includes transrectal ultrasonography and cystoscopic examination to assess the dimension and the conformation of the prostate as well as laboratory tests including PSA and renal function determination with urinalysis (56).

The potential to treat a patient with PUL under local anesthesia on an outpatient basis, as well as the minimal learning curve with only one to two procedures required to be proficient and around five procedures to reach optimal implant placement (53), make this an attractive therapeutic option for the management of BPO (40). The reported 1-year IPSS improvement of 46% seems superior to the approximately 35% to 40% improvement usually achieved after a period of alpha blockers (57) and similarly superior to the 15% to 30% improvement usually achieved after a minimum of two treatments with 5-alpha reductase inhibitors (58). Conversely, these results are unparalleled to the 75% improvement in IPSS reported 1-year after traditional surgical intervention (e.g., HoLEP) (56,59). These clinically relevant improvements in urinary symptoms appear to be sustained in the short-to-medium term despite the limited data that has been published (7,53,54).

It has been shown that PUL does not compromise erectile or ejaculatory function (38), and the ideal candidate is a patient with interest in maintaining potency and with mild LUTS (56,60,61). RCTs are awaited for this procedure. The L.I.F.T. study demonstrated in a multicenter randomized blind trial that the PUL provided rapid and sustained improvement in AUASI and flow without compromise of ejaculatory or erectile function(62).

Botulinum Toxin A Injection into the Prostate

Botulinum toxin (BTX) is the exotoxin of the bacterium *Clostridium botulinum*. This toxin is the most potent neurotoxin known in humans. Experience with intraprostatic injections for the treatment of LUTS/BPO exists only for onabotulinum toxin A (BTX-A). The mechanism of action of BTX-A in the prostate is not fully understood. In addition to blocking the release of neurotransmitters from presynaptic nerves (63), BTX-A reduces LUTS by induction of apoptosis of prostatic cells, leading to tissue atrophy and prostate size reduction (64–67). BTX-A inhibits the sensory prostatic neurons and reduces afferent signals to the central nervous system (65), with relaxation of smooth muscle cells in the prostatic parenchyma and reduction of BPO (65,68). Downregulation of 1A-adrenergic receptors in the prostate may contribute to smooth muscle cell relaxation (66). The latter two mechanisms are summarized as chemical denervation that may have a negative influence on prostate growth (11).

BTX injection into the human prostate was first reported in 2003 (69) in a small randomized trial comparing BTX with saline injection into the prostate. These initial results at 2 months following treatment appeared promising, with a 65% reduction in symptom scores, a 51% decrease in PSA levels, and a 33% reduction in prostate volume. No side effects to BTX injection were reported (7).

BTX can be injected directly into the prostate using transurethral, transrectal, or transperineal approaches, although the transperineal technique under transrectal ultrasound guidance has been the most common approach (7).

Practical Considerations. BTX-A injections into prostatic parenchyma appear to be a promising and quick minimally invasive treatment modality with low morbidity for patients who are refractory to medical treatment or in urinary retention. Nevertheless, BTX-A has been injected into only a limited number of patients, and all trials have only short-term follow-up (11).

A small study looking specifically at sexual function in 16 sexually active men was unable to establish any impact of BTX treatment on erectile, orgasmic, or ejaculatory function (7,68). Based on the limited available data, botulinum injection treatment into the prostate for LUTS/BPO remains promising but experimental (7).

TREATMENT OUTCOMES

The ultimate assessment of the efficacy of a surgical treatment for LUTS/BPO is a measure of its treatment outcome (see Table 30.5 and 30.6). The AUA Clinical Guidelines Panel on LUTS/BPO assessed the literature on surgical therapies in order to define the treatment outcomes for particular interventions (3).

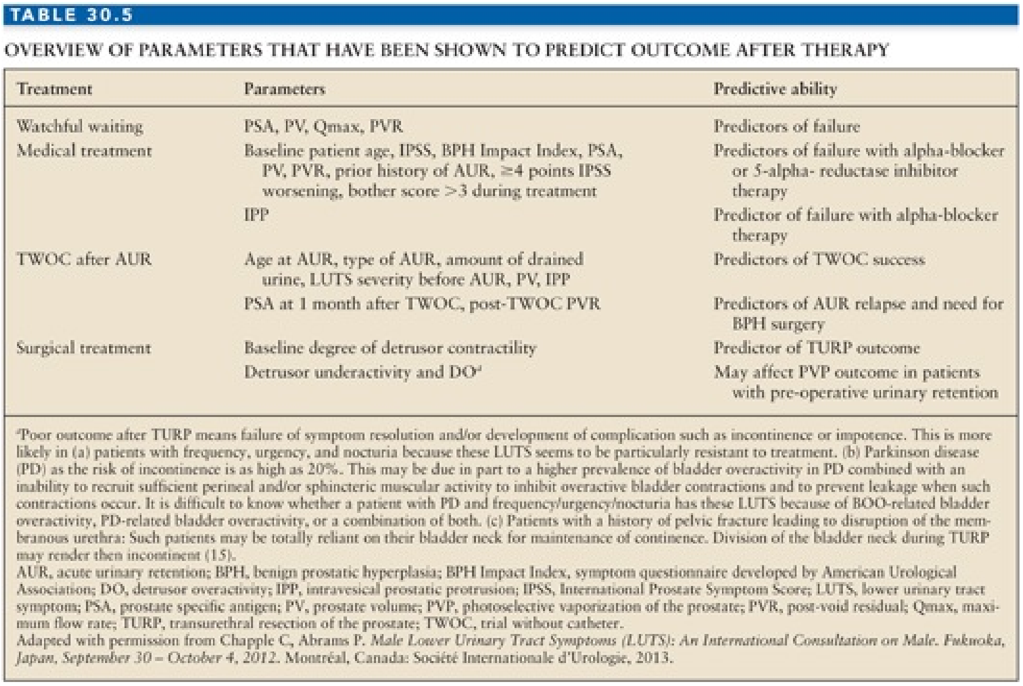

TABLE 30.5

OVERVIEW OF PARAMETERS THAT HAVE BEEN SHOWN TO PREDICT OUTCOME AFTER THERAPY

Treatment	Parameters	Predictive ability
Watchful waiting	PSA, PV, Qmax, PVR	Predictors of failure
Medical treatment	Baseline patient age, IPSS, BPH Impact Index, PSA, PV, PVR, prior history of AUR, ≥4 points IPSS worsening, bother score >3 during treatment	Predictors of failure with alpha-blocker or 5-alpha- reductase inhibitor therapy
	IPP	Predictor of failure with alpha-blocker therapy
TWOC after AUR	Age at AUR, type of AUR, amount of drained urine, LUTS severity before AUR, PV, IPP	Predictors of TWOC success
	PSA at 1 month after TWOC, post-TWOC PVR	Predictors of AUR relapse and need for BPH surgery
Surgical treatment	Baseline degree of detrusor contractility	Predictor of TURP outcome
	Detrusor underactivity and DO[a]	May affect PVP outcome in patients with pre-operative urinary retention

[a] Poor outcome after TURP means failure of symptom resolution and/or development of complication such as incontinence or impotence. This is more likely in (a) patients with frequency, urgency, and nocturia because these LUTS seems to be particularly resistant to treatment. (b) Parkinson disease (PD) as the risk of incontinence is as high as 20%. This may be due in part to a higher prevalence of bladder overactivity in PD combined with an inability to recruit sufficient perineal and/or sphincteric muscular activity to inhibit overactive bladder contractions and to prevent leakage when such contractions occur. It is difficult to know whether a patient with PD and frequency/urgency/nocturia has these LUTS because of BOO-related bladder overactivity, PD-related bladder overactivity, or a combination of both. (c) Patients with a history of pelvic fracture leading to disruption of the membranous urethra: Such patients may be totally reliant on their bladder neck for maintenance of continence. Division of the bladder neck during TURP may render then incontinent (15).

AUR, acute urinary retention; BPH, benign prostatic hyperplasia; BPH Impact Index, symptom questionnaire developed by American Urological Association; DO, detrusor overactivity; IPP, intravesical prostatic protrusion; IPSS, International Prostate Symptom Score; LUTS, lower urinary tract symptom; PSA, prostate specific antigen; PV, prostate volume; PVP, photoselective vaporization of the prostate; PVR, post-void residual; Qmax, maximum flow rate; TURP, transurethral resection of the prostate; TWOC, trial without catheter.

Adapted with permission from Chapple C, Abrams P. *Male Lower Urinary Tract Symptoms (LUTS): An International Consultation on Male. Fukuoka, Japan, September 30 – October 4, 2012*. Montréal, Canada: Société Internationale d'Urologie, 2013.

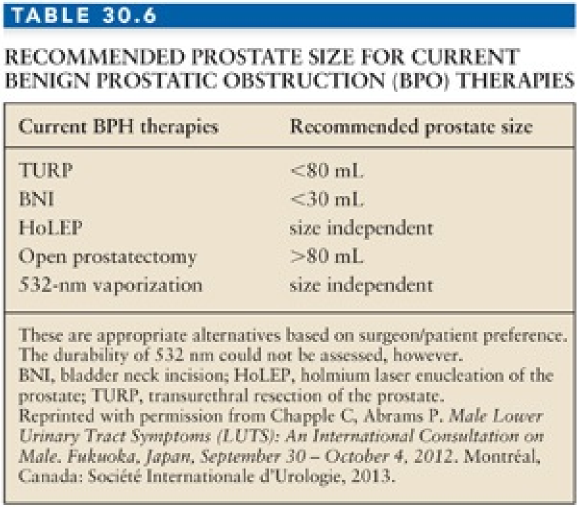

TABLE 30.6

RECOMMENDED PROSTATE SIZE FOR CURRENT BENIGN PROSTATIC OBSTRUCTION (BPO) THERAPIES

Current BPH therapies	Recommended prostate size
TURP	<80 mL
BNI	<30 mL
HoLEP	size independent
Open prostatectomy	>80 mL
532-nm vaporization	size independent

These are appropriate alternatives based on surgeon/patient preference. The durability of 532 nm could not be assessed, however.

BNI, bladder neck incision; HoLEP, holmium laser enucleation of the prostate; TURP, transurethral resection of the prostate.

Reprinted with permission from Chapple C, Abrams P. *Male Lower Urinary Tract Symptoms (LUTS): An International Consultation on Male. Fukuoka, Japan, September 30 – October 4, 2012*. Montréal, Canada: Société Internationale d'Urologie, 2013.

Surgical therapies remain a principal option in management of men with moderate to severe LUTS and/or those who are significantly bothered by these symptoms on maximal medical therapy. Open prostatectomy, TUIP, and M-TURP remain as gold standards by which newer transurethral approaches are compared (3). However, all laser therapies produce major improvements in the AUA Symptom Index scores. Although there are no direct comparisons between the various laser technologies, the improvements in symptom scores appear to be comparable to other surgical therapies and durable to 5 years (3). Laser therapies appear to offer similar improvements in postvoid residual and other urodynamic parameters compared to other surgical therapies such as TURP.

QoL data, a measure that is perhaps most important to the patient being treated, demonstrate equivalent improvements among all surgical technologies.

COMPLICATIONS

Endoscopic Surgery

One of the more common intraoperative complications for patients undergoing endoscopic surgical treatment of LUTS/BPO is bleeding, with hemorrhage requiring blood transfusion occurring in about 3% of cases (11). Due to the continuous irrigation flow and postoperative continuous bladder irrigation, it can often be difficult to estimate the magnitude of bleeding both during and following surgery. When bleeding is appreciated, a systematic inspection of the prostatic fossa will permit identification of the source, which can then be fulgurated with cautery or coagulated with the laser. If bleeding is refractory to these maneuvers, a Foley catheter placed on traction may be helpful.

Overaggressive resection may result in perforation of the prostatic capsule. Sequelae of this event may include extravasation of fluid into the retroperitoneum as well as electrolyte derangements. When a capsular perforation is encountered, it should be assessed. In the case of a small perforation, the procedure should be completed expeditiously. If a large perforation is identified, however, the procedure should be terminated. In the case of a retroperitoneal fluid collection, conservative management (catheter drainage and furosemide) is a reasonable approach because these contained collections generally reabsorb spontaneously. If the perforation is extensive, however, TUR syndrome may occur, although this is a rare event occurring in approximately 1% of cases (11). This condition, brought about by intravascular absorption of hypotonic irrigating solutions ultimately inducing a dilutional hyponatremia, can be associated with hypertension, mental confusion, and nausea and vomiting. TUR syndrome can be managed by diuresis and repletion with normal saline intravenous fluid or, in extreme circumstances, hypertonic (3%) saline in small (e.g., 100 mL) boluses.

Structures in the vicinity of the prostate may also be injured in the course of endoscopic surgical treatment. In some patients, the ureteral orifice may be close to the bladder neck and can be inadvertently ablated or resected. Should the ureteral orifice be injured, an attempt should be made to stent the ureter at the conclusion of the procedure. Stricture formation is the most concerning sequelae of this complication and occurs in about 4% of patients (11). The bladder neck may also be undermined, which can complicate the placement of a catheter at the conclusion of the procedure and lead to bladder neck contracture in approximately 5% of patients. In severe cases, the bladder and prostatic urethra can become completely dissociated. If the bladder neck is identified as being undermined, a Foley catheter should be placed with a catheter guide, or preferably over a wire, to ensure proper placement.

Transient urinary incontinence or urinary retention may occur following an endoscopic prostate resection or ablation. These symptoms generally resolve in the weeks following the procedure. Permanent stress urinary incontinence (11) or retention following these procedures is exceedingly rare. All patients who undergo any of these previously described procedures will experience retrograde ejaculation (11) and should be forewarned of this eventuality. In the analysis of 29 randomised controlled trials (RCTs), the incidence of erectile dysfunction (ED) following TURP was 6.5% (11), and this is thought to be caused by confounding factors (e.g., age) rather than being the direct consequence of TURP. Patients with preoperative urinary retention are at increased risk for postoperative complications (70).

Open Surgery

Severe bleeding following open prostatectomy has been documented to occur in up to 35% of patients; blood transfusion rates are similarly high (7,47). Urinary clot retention has been reported to occur following open prostatectomy procedures and may require both manual and, less commonly, cystoscopic evacuation of clot from the bladder. Urinary leakage from the cystotomy is not uncommon following catheter removal and generally resolves within 1 to 2 days. Transient urgency urinary incontinence occurs following open surgical prostatectomy, usually due to bladder overactivity, but this generally resolves within several weeks of surgery. Retrograde ejaculation occurs in all patients undergoing prostatic adenomectomy. ED ranks sixth after symptomatic improvement, incontinence, immediate surgical complications, mortality, and complications requiring surgery (7,71). Long-term complications from open surgery are incontinence, bladder neck contracture, and urethral stricture. The risk of developing stress incontinence is up to 10% (4), whereas the risk for developing bladder neck contracture and urethral stricture is about 6% (11,44–46). The etiology of bladder neck contracture is unclear, and treatment may require dilation or even incision of the bladder neck.

Conclusion

The choice of the surgical technique depends on prostate size, patient comorbidities, fitness for anesthesia, patient preferences, willingness to accept the respective surgery-specific side effects, availability of each treatment, and experience of the surgeon with these operative techniques. Transurethral resection remains the gold standard, but when available, new therapies could be considered. The best available evidence currently, based on RCTs, is for B-TURP, HoLEP, and GreenLight laser treatment with selective indications for open and minimally invasive simple prostatectomy (7).

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CHAPTER 31 OPEN RADICAL RETROPUBIC PROSTATECTOMY

DAVID GILLATT AND SANDIP M. PRASAD

Until the last decade, open radical retropubic prostatectomy (RRP) had become the surgical procedure of choice to effect cure in men with clinically localized prostate cancer and a life expectancy that rendered them at risk of death from their cancer (1). In appropriately selected patients, total removal of the prostate gland with preservation of neurovascular bundles, where appropriate offers a high rate of cure of the cancer. In those men with risk factors suggesting a chance of microscopic breach of the prostatic capsule by the cancer, wider excision without neurovascular bundle (NVB) preservation is more appropriate. If other risk factors for disease progression are present, RRP should be combined with concomitant excision of pelvic lymph nodes.

Walsh and Donker (2) pioneered the anatomic understanding of the prostate and its surrounding structure, which allows us now to understand the nuances of a complex procedure where the surgeon is attempting to cure a cancer but retain both urinary and sexual function where possible. In order to perform this operation, the surgeon must have a mastery of this anatomy, including the periprostatic fascia, the position of the NVB, and the structure of the distal urethral sphincter mechanism. Subsequent modifications of the technique, which will be described in this chapter, have allowed improved visualization of the structures, improved hemostasis, and preservation of the anatomy while margin positivity rates have reduced (3).

The open retropubic approach for this procedure remains in common usage around the world, although in many Western countries, RRP is rapidly being superseded by laparoscopic or robot-assisted techniques. This chapter describes the open RRP operation and is based on our cumulative experience of >2,000 cases and the collective experience in the urologic literature.

INDICATIONS

The indications for any form of radical prostatectomy are largely the same. For the small number of men in whom access via the retropubic space is difficult or impossible, the perineal approach may be preferred. In the early days of the modern procedure, the prevailing paradigm was to treat all men with “curable” localized prostate cancer. However, this approach resulted in considerable overtreatment of men with cancers at low risk of progression in their lifetime given the long natural history of the disease (4). More recently, adoption of expectant management approaches to localized prostate cancer suggests that surgery may best serve younger men (younger than age 65 years) and those with intermediate risk disease (5). In general, for these men, a predicted life expectancy of 10 years or older is needed for the benefits of prostate cancer treatment to manifest.

PREOPERATIVE PREPARATION

Preoperative counseling for RRP is vitally important as men will have temporary and occasionally permanent effects on sexual and urinary function postoperatively. We recommend that this process occur over several visits to allow for an informed and participatory discussion between surgeon and the patient and his family. For men to be satisfied with their treatment decision, a thorough and informed consent is critical.

Given the low rate of rectal injury and lack of strong evidence favoring improved outcomes with mechanical bowel preparation, we do not routinely use bowel preparation except for an enema in certain clinical scenarios, namely, salvage surgery following radiation, brachytherapy, and high-intensity focused ultrasound or after previous rectal surgery (6). In the preoperative holding area, prophylactic antibiotics are started prior to incision. For prophylaxis against thromboembolism, we use a regimen of elastic compression stockings, sequential pneumatic compression devices, and subcutaneous heparin (5,000 units) prior to induction of the anesthesia and throughout the postoperative period until patients are routinely ambulating (typically postoperative day 1).

Patients are positioned supine on the operating room table with mild dorsiflexion with the break positioned just above the anterosuperior iliac spine to open the pelvis and improve access and visualization of the retropubic space. The patient's legs may be positioned on spreader bars to facilitate a second surgical assistant (Fig. 31.1). Typically, RRP is performed with general anesthesia, but some advocate for the use of epidural or spinal anesthesia (7). With the increasing adoption of minimally invasive approaches to radical prostatectomy with their shorter lengths of stay and postoperative narcotic requirements, proponents of RRP have incorporated more aggressive use of non-narcotic anesthesia (standing Tylenol and Toradol) and local anesthetic techniques (e.g., transabdominal plane [TAP] block) to reduce postoperative opiate use and facilitate early mobilization and discharge.

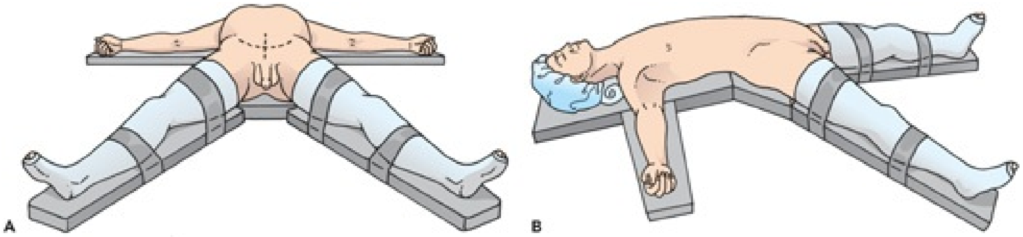

FIGURE 31.1 A and B: Positioning of the patient. Legs are separated on spreader bars. The operating table is flexed with the break just above the patient's anterosuperior iliac spine. (Adapted with permission from Han M, Catalona WJ. Ch. 29, Anatomic nerve-sparing radical retropubic prostatectomy. *Urol Oncol* 2005;514–527. Copyright © 2005 Elsevier Inc. All rights reserved.)

OPERATIVE TECHNIQUE

Incision

Classically, an 8- to 10-cm lower midline incision is used. This allows access to the extraperitoneal retropubic space and the pelvic lymph nodes. The incision should commence over the superior aspect of the pubic bone and travel cranially. The skin and subcutaneous fat is incised and the rectus sheath opened along the linea alba. To facilitate identification of the linea alba, a retractor can be used at the apex of the incision with cranial retraction; the linea alba can then easily be palpated. The recti muscles can be parted in the midline with blunt dissection to create an extraperitoneal space which can give excellent access to the retropubic space of Retzius. Typically, the insertion of the recti abdominis muscles are divided with electrocautery to their attachment to the pubis. Blunt dissection is again performed to free the perivesical and periprostatic alveolar tissue from the pelvic side wall, and the external iliac artery and vein should be visualized bilaterally. A self-retaining retractor of appropriate size should be used; we prefer the Balfour or Bookwalter retractor for this incision.

It is possible to perform this operation through a standard Pfannenstiel incision although a randomized controlled trial did not demonstrate significant differences in need for postoperative analgesia and time to recovery compared with a standard vertical laparotomy (8). The Pfannenstiel incision may restrict access to the immediate retropubic space and make lymphadenectomy more difficult, although it allows for concomitant inguinal hernia repair.

Pelvic Lymphadenectomy (If Indicated)

Current National Comprehensive Cancer Network (NCCN) guidelines recommend the performance of pelvic lymph dissection in men with a predicted probability of lymph node metastasis greater than or equal to 2% (9).

The decision to perform standard versus extended pelvic lymph node dissection remains primarily driven by surgeon preference because the number of lymph nodes resected does not appear to affect disease-specific survival in men without positive nodes (10). In addition, a conversation should occur preoperatively with the patient with high-risk disease about his preferences regarding prostatectomy in the event that positive lymph nodes are found; if the patient would elect to forgo prostatectomy in the setting of metastatic disease, the pelvic lymph nodes should be sent for frozen section.

The surgical template for extended pelvic lymph node dissection extends from the bifurcation of the common iliac artery superiorly, the femoral canal inferiorly, and the obturator nerve and vessels and the hypogastric artery posteriorly. The standard template differs by exclusion of the lymphatic tissue overlying the hypogastric artery. Only those lymph nodes medial to the hypogastric vein should be removed and arterial branches from the external iliac, and obturator arteries should be preserved as these may supply the corpora cavernosa. Care should be taken to clearly identify, preserve, and avoid excessive traction to the obturator nerve.

Identification and Preparation of the Prostate

An often underrated step is the removal of fat and areolar tissue from the anterior surface and apex of the prostate in order to facilitate precise identification of relevant anatomy. This is best achieved by the use of a combination of blunt dissection with a peanut swab and limited use of electrocautery superficially when veins are encountered from prostatic apex to the bladder neck.

Incision of the Endopelvic Fascia

The endopelvic fascia is incised sharply or with electrocautery in the groove between the levator ani muscles and the lateral border of the prostate (Fig. 31.2). This groove can be clearly visualized with medial retraction of the prostate using a sponge stick. Inside the fascia, the lateral surface of the prostate is covered by a smooth membrane overlying the lateral portion of the Santorini plexus. Strands of the levator ani muscles are gently dissected off the prostate to the level of the urogenital diaphragm using a peanut swab. There is often a small vein just lateral to the puboprostatic ligaments, and this should be cauterized adjacent to the prostate. The endopelvic fascia should be opened from the apex to the base of the prostate, taking care to avoid the deeper veins of the DVC. There is often debate whether the puboprostatic ligaments should be divided or preserved at this point. If the decision is made to divide the puboprostatic ligaments, they should be divided close to the pubis to facilitate access to the dorsal vein complex (DVC) (Fig. 31.3).

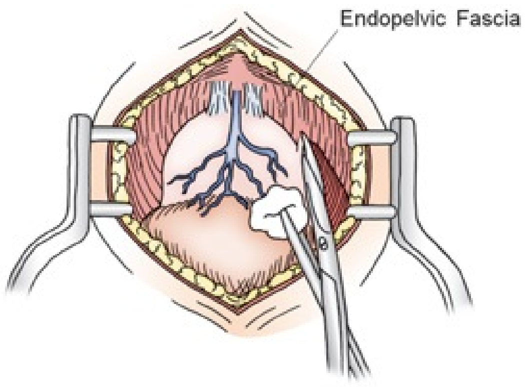

FIGURE 31.2 The endopelvic fascia is incised in the groove between the levator ani muscles and the lateral border of the prostate. (Adapted with permission from Han M, Catalona WJ. Ch. 29, Anatomic nerve-sparing radical retropubic prostatectomy. *Urol Oncol* 2005;514–527. Copyright © 2005 Elsevier Inc. All rights reserved.)

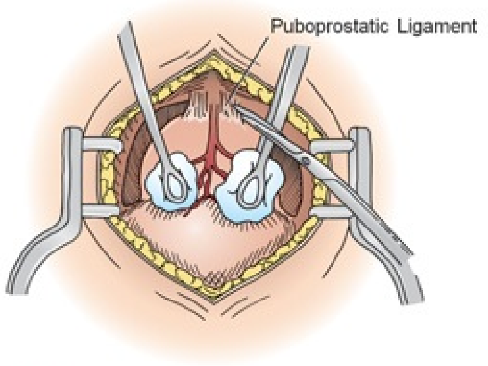

FIGURE 31.3 The puboprostatic ligaments are placed on stretch and incised. (Adapted with permission from Han M, Catalona WJ. Ch. 29, Anatomic nerve-sparing radical retropubic prostatectomy. *Urol Oncol* 2005;514–527. Copyright © 2005 Elsevier Inc. All rights reserved.)

Ligation of the Dorsal Vein Complex

The DVC and urethra can be gently retracted medially allowing access to the plane between DVC and urethra. If the DVC is difficult to access, an atraumatic clamp such as a Babcock or Allis may be used to grasp the DVC (but not the urethra). Lifting this clamp anteriorly will open the space between DVC and urethra, facilitating subsequent suture placement. The fibers of the striated distal urethral sphincter should be observed wrapping around the urethra as part of the complex. A 2-0 absorbable suture on a CT-1 needle is typically used to suture ligate the DVC (Fig. 31.4). The needle should be pushed straight through the notch between the DVC and urethra as distally as can be placed and rotated only after the needle tip emerges on the opposite side. A simple ligation will usually suffice, but some surgeons advocate a figure-of-eight suture for control of a broader DVC or improved hemostasis. Occasionally, it may be useful to pass the needle through the periosteum of the posterior pubis just anterior to the DVC. If the suture is then tied, it will both control the DVC and anchor it to the periosteum, facilitating underrunning of any bleeding points after transection. A 3-0 absorbable suture on a 5/8 or UR needle is an excellent tool for dealing with bleeding in this area. A second caudal (Fig. 31.4) or “back-bleeding” suture on the anterior surface of the prostate (Fig. 31.5) may be used and is often best applied in a running inverted V over the anterior surface of the prostate for hemostasis. Once ligated, the DVC should be divided initially with a curved dissecting scissors, electrocautery, or scalpel (Fig. 31.6), allowing the curve to guide over the apex to the urethra just distal to the prostate. Lateral dissection around the urethra should be kept to a minimum to avoid the NVB at this point.

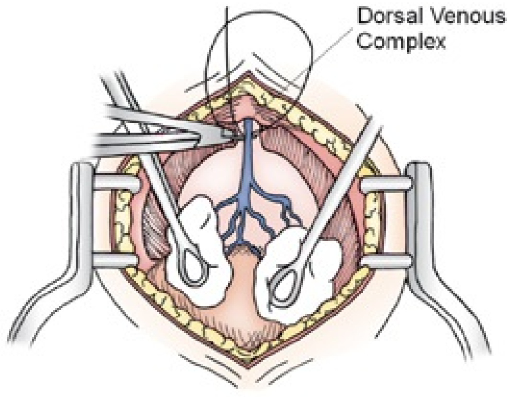

FIGURE 31.4 DVC is suture ligated with a 2-0 chromic catgut suture on a CT-1 needle. (Adapted with permission from Han M, Catalona WJ. Ch. 29, Anatomic nerve-sparing radical retropubic prostatectomy. *Urol Oncol* 2005;514–527. Copyright © 2005 Elsevier Inc. All rights reserved.)

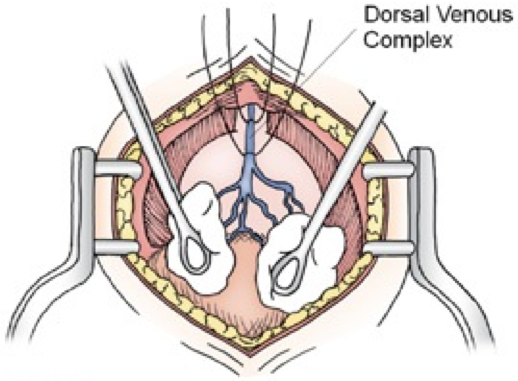

FIGURE 31.5 To reduce back bleeding from the Santorini plexus, the cephalad aspect of the DVC is suture ligated. (Adapted with permission from Han M, Catalona WJ. Ch. 29, Anatomic nerve-sparing radical retropubic prostatectomy. *Urol Oncol* 2005;514–527. Copyright © 2005 Elsevier Inc. All rights reserved.)

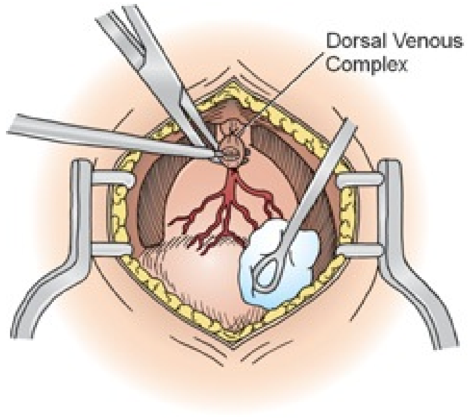

FIGURE 31.6 DVC is transected with a right-angle clamp jaws spread behind the complex. (Adapted with permission from Han M, Catalona WJ. Ch. 29, Anatomic nerve-sparing radical retropubic prostatectomy. *Urol Oncol* 2005;514–527. Copyright © 2005 Elsevier Inc. All rights reserved.)

Dividing the Urethra

After complete hemostasis is achieved, the anterior urethra should be immediately visualized. It can be opened with a scalpel or dissecting scissors (Figs. 31.7 and 31.8), and the urethral catheter is delivered through the urethrotomy into the pelvis. The catheter can be divided between two Kelly clamps and will be subsequently used to gently retract the urethra (and later the prostate). At this point, urethral sutures for the vesicourethral anastomosis can be pre-placed. Perineal pressure by the assistant with a sponge forceps may facilitate placement (Fig. 31.9). Six 4-0 Monocryl sutures are inserted into the distal urethral margin, equally spaced circumferentially. The sutures should be anterolateral, lateral, and posterolateral on either side. These sutures should have a 5/8ths needle on either end which can be used later to place the sutures through the bladder neck to achieve the vesicourethral anastomosis. Following placement of the urethral sutures, the posterior wall of the urethra and the “rectourethralis” fibers are divided (Fig. 31.10).

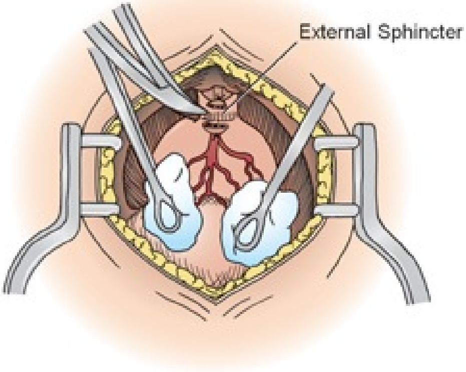

FIGURE 31.7 The circumurethral external sphincter muscle fibers are incised to expose the urethra. (Adapted with permission from Han M, Catalona WJ. Ch. 29, Anatomic nerve-sparing radical retropubic prostatectomy. *Urol Oncol* 2005;514–527. Copyright © 2005 Elsevier Inc. All rights reserved.)

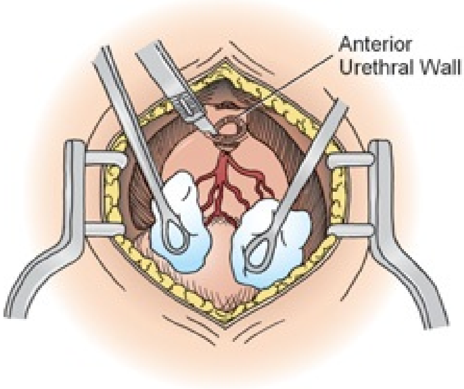

FIGURE 31.8 The anterior wall of the urethra is incised with a scalpel without dissecting around the lateral or posterior surfaces of the urethra. (Adapted with permission from Han M, Catalona WJ. Ch. 29, Anatomic nerve-sparing radical retropubic prostatectomy. *Urol Oncol* 2005;514–527. Copyright © 2005 Elsevier Inc. All rights reserved.)

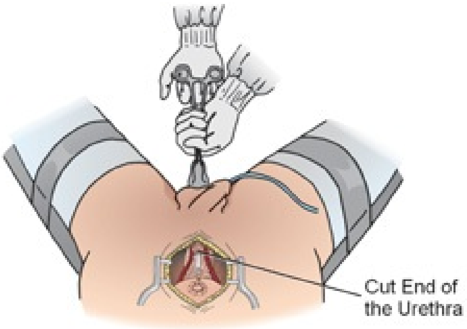

FIGURE 31.9 Perineal pressure is applied with a sponge forceps to better expose the cut end of the urethra. (Adapted with permission from Han M, Catalona WJ. Ch. 29, Anatomic nerve-sparing radical retropubic prostatectomy. *Urol Oncol* 2005;514–527. Copyright © 2005 Elsevier Inc. All rights reserved.)

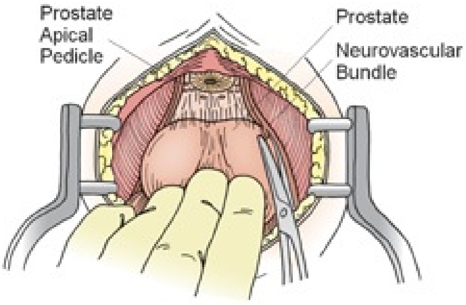

FIGURE 31.10 The apical pedicles of the prostate may require suture ligation. Fibromuscular bands tethering the apex of the prostate to the pelvic floor are incised using sharp dissection. The prostate gland is dissected from NVBs. (Adapted with permission from Han M, Catalona WJ. Ch. 29, Anatomic nerve-sparing radical retropubic prostatectomy. *Urol Oncol* 2005;514–527. Copyright © 2005 Elsevier Inc. All rights reserved.)

Neurovascular Bundle Preservation (“Nerve Sparing”)

An understanding of the position and route of the NVB is critical to perform precise anatomic nerve sparing. In order to separate the NVB from the prostate and preserve it, the lateral pelvic fascia should be opened initially with sharp dissection from apex to the base of the prostate. We perform a high anterior release of the fascia because this is associated with an improved chance of preserving nerve fibers which are often spread across the anterolateral aspects of the gland as well as sitting in the groove between the prostate and rectum posterolateral. It is also important to gently sweep away the bundle from the apex of the prostate at the lateral aspect of the urethra in order to avoid damage. By gently teasing the bundles off the prostate, a plane should develop allowing the prostate to be dissected away from the rectum. Small vessels, mainly veins, may be controlled with clips or ties. The dissection continues toward the bladder neck until the fascia covering the vas and seminal vesicles (SVs) is identified and the prostatic vascular pedicles are isolated. This step can be more difficult if there is periprostatic fibrosis and anecdotally this seems more common in the era of transperineal biopsy and again more recently in the era of active surveillance, where men may undergo multiple biopsies prior to surgery. Prior to embarking on nerve sparing, a decision regarding its suitability should be made in light of each individual’s tumor type and location.

It is possible to mobilize the NVB at the apex just lateral to the urethra and sweep it away from the prostate at this point. This can be a useful maneuver when fibrosis is present in the lateral prostate. However, it does run the risk of entering veins constituting part of the DVC. Dissection toward the bladder will often reveal the prostatic vascular pedicles, which at this point can be suture ligated or clipped. This stage of the procedure can also be performed prior to division of the urethra resulting in lateral mobilization of the prostate and creating a “valley” laterally between prostate and rectum.

Posterior Mobilization

After mobilization of the NVBs and division of the urethra beyond the apex, the prostate should be mobilized from the rectum by gentle blunt dissection. It should be possible to insert a finger between the rectum and prostate in the midline. If mobilization of the NVB is complete, the prostate should lift completely away from the rectum. Anterior and cranial retraction of the prostate will expose Denonvilliers fascia over the ampullae of the vasa and SVs (Fig. 31.11). It is often necessary to clip and divide a few remaining posterolateral fibers to completely mobilize the lateral prostate.

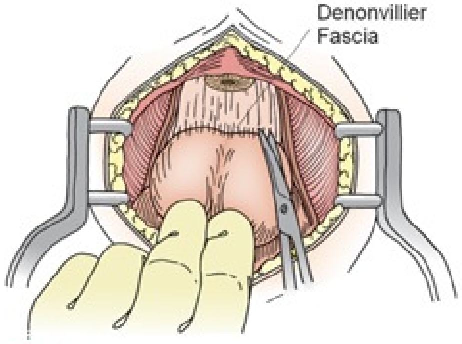

FIGURE 31.11 The dissection is carried cephalad until the portion of the Denonvilliers fascia covering the ampullary portions of the vasa deferentia and the SVs are exposed. The Denonvilliers fascia is incised with cautery to expose vascular pedicles at prostate base. (Adapted with permission from Han M, Catalona WJ. Ch. 29, Anatomic nerve-sparing radical retropubic prostatectomy. *Urol Oncol* 2005;514–527. Copyright © 2005 Elsevier Inc. All rights reserved.)

Control of the Prostatic Vascular Pedicles

Vascular control of the prostatic pedicles is best achieved by using a right angle clamp passed medial to the pedicle, with the direction of control parallel to the prostatic surface from cranial to caudal and medial to the NVB. Initially, hemostatic clips are applied (Fig. 31.12) before division with sharp scissors, although often it is wise to also suture ligate the pedicle. The anatomy of the pedicles is quite variable and may require more than a single point of control.

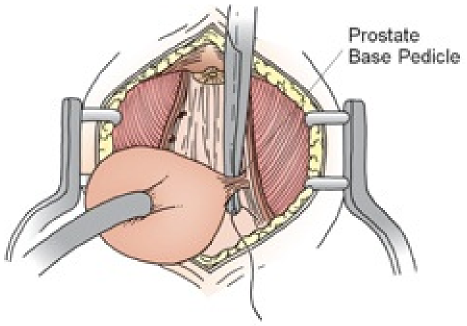

FIGURE 31.12 The prostate base pedicle is ligated or hemoclipped laterally, taking care to place the tie medial to the NVB. (Adapted with permission from Han M, Catalona WJ. Ch. 29, Anatomic nerve-sparing radical retropubic prostatectomy. *Urol Oncol* 2005;514–527. Copyright © 2005 Elsevier Inc. All rights reserved.)

Opening of Denonvilliers Fascia and Dissection of the Seminal Vesicles

The prostate should now be mobile and easily delivered anteriorly toward the wound. The Foley catheter is in situ with the balloon inflated and a clamp across the tube distal to the prostatic apex and acts as a retractor and deflects the gland in appropriate directions to allow access to posterior structures. With the catheter holding the prostate in the midline and exposing Denonvilliers fascia, mobilization of the SVs can begin. At this point, Denonvilliers fascia has two layers. The layers should be incised over the SVs in the midline in a horizontal direction. Both layers should be incised to expose the vesicles laterally; the ampullae of the vasa deferentia will lie in the midline but in many cases will be obscured by the medial aspect of the SVs. In order to access the vasa, it may be necessary to sweep away the medial aspects of the SVs. A right-angle clamp should be passed behind the vas and blunt dissection used to free a 1- to 1.5-cm segment of each vas. The vas should be clipped away from the base of the gland and divided. The vas can subsequently be used to gain access to the medial and posterior aspects of the SVs. The SVs can be mobilized by blunt and sharp dissection. Typically, one will encounter several small perforating vessels, which require clipping. The vascular pedicle at the tip of each SV should be clipped and divided.

Transection of the Bladder Neck

Once the SVs are mobilized and the pedicles divided, the prostate is only attached to the bladder neck. There are several ways to deal with the bladder neck. The most straightforward is to take an anterior approach. In order to identify the “true bladder neck,” it may be useful to fix the intravesical portion of the urethral catheter with a Babcock-type atraumatic clamp taking the bladder wall and catheter en masse. By manipulating the catheter, the junction between bladder and prostate can be identified. Electrocautery is used to open the anterior bladder neck and to identify the catheter in the bladder. The catheter balloon is deflated and the intravesical portion is delivered out of the vesicostomy. The two ends of the catheter should be clamped together and again used for retraction (Fig. 31.13). The bladder neck defect can be widened with electrocautery, and the urothelial of the posterior bladder neck transected. Prior to this, the ureteric orifices should be identified and avoided. If, because of prior transurethral resection of the prostate or a large intravesical lobe they are close to the transection line, the surgeon may consider passing ureteric catheters or a 5Fr pediatric feeding tube to localize and protect the lower ureters. These should be kept in place until the bladder neck is reconstructed. Once the posterior bladder neck is safely transected, the muscular fibers between prostate and bladder can be divided with electrocautery to completely free the prostate for pathologic examination.

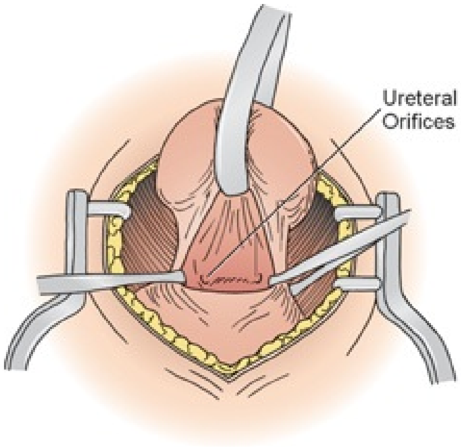

FIGURE 31.13 The anterior bladder neck is transected in the natural groove between the bladder and the prostate. The bladder neck opening is enlarged with scissors. The ureteral orifices are identified. (Adapted with permission from Han M, Catalona WJ. Ch. 29, Anatomic nerve-sparing radical retropubic prostatectomy. *Urol Oncol* 2005;514–527. Copyright © 2005 Elsevier Inc. All rights reserved.)

Reconstruction of the Bladder Neck

It is useful to try and preserve the bladder neck where possible to promote an early return to continence and, if so, only minimal reconstruction should be necessary. If the bladder neck is approximately the diameter of a 22Fr or 24Fr catheter, then the surgeon may simply evert the mucosa by placing 4-0 absorbable suture at 5 or 6 points circumferentially around the bladder neck or with a continuous running everting suture circumferentially around the bladder neck (Fig. 31.14). These everting sutures should be between bladder mucosa and the outer surface of bladder muscle. When a wider defect is present, formal reconstruction of the bladder neck is appropriate. This is best performed in an inverted Y (“tennis racket”) fashion. A 3-0 Monocryl suture is placed at the posterolateral apex of the defect on either side and run until they meet in the midline. The remaining small anterior defect is the new bladder neck; infrequently, if this remains large, further closure can be performed anteriorly to create an appropriately sized bladder neck.

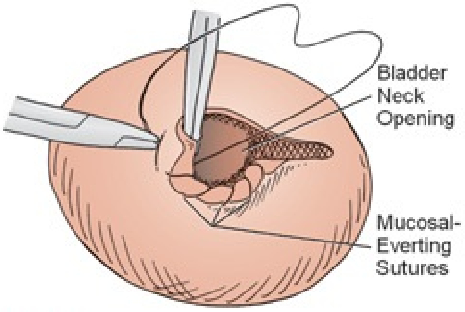

FIGURE 31.14 A continuous running mucosa-everting suture of 3-0 chromic catgut is placed for a distance of nearly the entire anastomotic circumference. (Adapted with permission from Han M, Catalona WJ. Ch. 29, Anatomic nerve-sparing radical retropubic prostatectomy. *Urol Oncol* 2005;514–527. Copyright © 2005 Elsevier Inc. All rights reserved.)

Vesicourethral Anastomosis

The preplaced six 3-0 Monocryl sutures in the urethra are now placed into their corresponding locations in the bladder neck (Fig. 31.15). If double-armed suture is not available, a French eye needle may be used to place the suture inside-out through the bladder neck. An 18Fr catheter is passed down the urethra and delivered into the pelvis anterior to the posterolateral sutures. The bladder can then be “parachuted” down onto the urethra with a sponge stick to reduce tension, and the sutures are then tied carefully to bring bladder neck and urethra into apposition over the Foley catheter. Integrity of the anastomosis should be tested by filling the bladder with at least 180 mL saline to ensure that it is watertight.

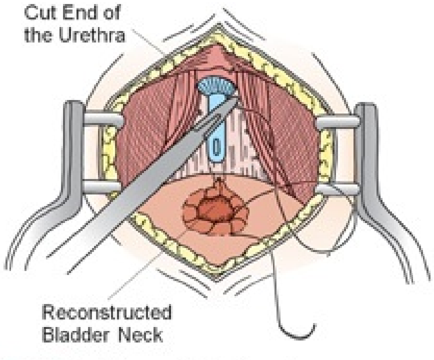

FIGURE 31.15 Double-armed 2-0 chromic catgut sutures are used for the vesicourethral anastomosis. (Adapted with permission from Han M, Catalona WJ. Ch. 29, Anatomic nerve-sparing radical retropubic prostatectomy. *Urol Oncol* 2005;514–527. Copyright © 2005 Elsevier Inc. All rights reserved.)

Wound Closure

After full hemostasis is achieved, the wound may be closed. Typically, adjunct hemostatic agents (e.g., Surgicel, FloSeal) are not necessary. A continuous nonabsorbable running mass closure of the abdominal wall is appropriate. The skin may be closed with clips or an absorbable subcuticular suture. The wound should be infiltrated into the deep layers with local anesthetic. A small drain is left in the pelvis during the postoperative period and removed prior to discharge if there is no evidence of bleeding or urine leak.

POSTOPERATIVE CARE

The analgesic requirement following surgery varies but with a good wound block may be minimal. However, a significant proportion of men require opiate analgesia for the first 12 to 24 hours. To minimize this, we advocate for the standing use of non-narcotics such as acetaminophen and nonsteroidal anti-inflammatory medications such as Toradol or ibuprofen on every 6 hours basis. Adopting these non-narcotic pathways has been shown to result in similar low narcotic use and pain scores compared with minimally invasive approaches (11). The patient can start a normal diet as soon as he feels able. Early ambulation is critical and patients should be up and out of bed on the evening of surgery and walking on the first postoperative day. Most patients are discharged home on postoperative day 1 or 2, with the drain removed prior to discharge if there is no concern for urine leak.

The urethral catheter can be removed without a cystogram in 7 to 10 days.

COMPLICATIONS

Massive intraoperative hemorrhage was an early concern of RRP, with more recent high-volume centers reporting perioperative transfusion rates of 20% (12). Careful and meticulous technique during control of the DVC and prostatic pedicles reduces blood loss considerably. In the authors' last 500 cases, no patient has required transfusion. Significant hemorrhage should be an uncommon complication of modern RRP. The rectum can rarely be injured during RRP, particularly if there is marked fibrosis around the apex of the gland. If recognized and there is not gross spillage of stool into the wound, the defect can be repaired with two layers of 3-0 Monocryl and prophylactic antibiotics commenced in the immediate postoperative period. Ureteric injury can also rarely occur when there has been previous bladder neck surgery. If recognized, the ureter can be sutured to the bladder mucosa with 4-0 Vicryl and the bladder neck subsequently reconstructed while protecting the ureters with stents.

The most common postoperative complications of anatomic nerve-sparing RRP include anastomotic stricture (bladder neck contracture), thromboembolic complications (deep vein thrombosis and pulmonary embolism), and postoperative inguinal hernia. The rate of bladder neck contracture in expert series has been as low as 1% (13), although a large population-based analysis suggests that the rate is closer to 14% (14). Thromboembolic complications were seen in 2.2% of patients undergoing open radical prostatectomy in a recent large, multicenter prospective controlled trial (15); these were 4 times more common when lymph node dissection was performed and was 4 times more common with RRP than robot-assisted laparoscopic radical prostatectomy. In the Scandinavian Prostate Cancer Group 4 study, a prospective randomized study between RRP and watchful waiting with a follow-up of over 12 years, 9.3% of subjects developed inguinal hernia after RRP within 48 months as compared to 2.4% in a group of men managed without surgery (16).

A comprehensive discussion of urinary and erectile function is beyond the scope of this chapter and in the absence of a large head-to-head comparative randomized clinical trial is limited by the quality of the available comparative studies (17). This said, it appears clear that functional outcomes are improved with increasing cumulative number of RRP performed by the surgeon and hospital (18) and we would endorse dissemination of the techniques and processes of care described in this chapter to accelerate this process in low volume surgeons.

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CHAPTER 32 RADICAL PERINEAL PROSTATECTOMY

SAM D. GRAHAM JR. AND THOMAS E. KEANE

Radical perineal prostatectomy, first performed in 1869 by Buchler and popularized in the United States by Young in 1903, remained the primary surgical approach to carcinoma of the prostate into the mid-1970s. With the recognition of the importance of assessing advanced (nodal) disease preoperatively, which if positive would halt the operative procedure, and the advantage that retropubic prostatectomy offered with the concomitant pelvic node dissection, perineal prostatectomy declined in popularity for the treatment of prostate cancer. The perineal approach, however, saw a resurgence in the 1990s for several reasons: (a) the trend toward minimally invasive surgery with a focus on reducing the morbidity and therefore hospital stay of patients, (b) the advent of laparoscopic surgery for lymph node assessment, (c) the introduction of prostate-specific antigen (PSA) for screening for prostate cancer with reduction in the numbers of patients with node-positive disease, (d) algorithms that may predict patients at high risk for positive lymph nodes, and (e) increased recognition of similar results compared to all other methods of radical prostatectomy. The procedure is also associated with reduced blood loss and low morbidity, and it can be modified to incorporate the neurovascular-sparing techniques for preservation of potency.

DIAGNOSIS

All patients who are potential candidates for radical perineal prostatectomy should undergo appropriate preoperative staging to ensure that they are operable candidates; preoperative imaging is rarely required in low- to intermediate-risk patients. Methods of differentiating local versus advanced disease include digital rectal examination, transrectal ultrasonography, radionuclide bone scan, assessment of pelvic lymph nodes, and pathologic indicators of progression such as Gleason sum and other markers.

PSA screening has made a significant impact on the preoperative stage of patients with prostate cancer. Patients presenting for surgery are generally younger, healthier, and more likely to have organ-confined prostate cancer than the population treated prior to PSA introduction, and in many ways, this attributes to the large increase in the number of radical prostatectomies done in the United States in the PSA era.

Digital rectal examination has a limited role in the clinical staging of prostate cancer. It is primarily used to crudely estimate the volume of the cancer. Transrectal ultrasonography is another modality that also has limitations in assessing local disease, but combined with digital rectal examination, it at least gives some gross assessment of the likelihood of extracapsular disease. Other modalities, such as fused-transrectal ultrasound and magnetic resonance imaging (MRI), computerized tomography (CT) scan, and pelvic MRI, have been shown to have limited usefulness. The new generation of MRI scanners and ProstaScint scanning using fusion technology with CT or MRI have the potential to improve prostate cancer staging. Radionuclide bone scans are useful in assessing advanced bone disease but generally are not positive in patients with PSAs below 20 and no other sign of advanced disease.

For the past 20 years, we have prospectively provided data that has been applied to an algorithm for the preoperative assessment of patients with prostate cancer developed through data on over 400 patients who had undergone pelvic node dissection. The current algorithm includes patients with a Gleason sum of 7, providing that the predominant pattern is 3, a low-volume cancer (T1b-c, T2a), and PSA of <10 ng per mL. Patients meeting all of these criteria have a <5% chance of positive lymph nodes, and therefore, we do not routinely perform pelvic lymph node dissections (1). Patients exceeding any one of the previously described criteria are considered to be in the high-risk group and have undergone pelvic lymph node dissections. Using this method of assessment, our overall PSA recurrence rate from 1986 to 1993 was 24%. This compares favorably to other series of retropubic prostatectomies from that time in which all patients had a node dissection; in those series, PSA recurrence rates were between 24% and 28% (2–5).

INDICATIONS FOR SURGERY

Patients who are candidates for radical prostatectomy must have clinically organ-confined prostate cancer (T1-2). Other factors that need to be taken into consideration are the patient’s life expectancy, other comorbidities, or any other factors that may affect the patient’s choice. We generally do not offer a radical prostatectomy to patients who have a <10-year expectancy. Over the age of 70, we offer a radical prostatectomy only in selected cases where we feel that the benefits that can be obtained from radical prostatectomy outweigh the potential risks, particularly when compared to alternative therapies.

ALTERNATIVE THERAPY

Alternatives to perineal prostatectomy include retropubic and laparoscopic or robot-assisted laparoscopic prostatectomies. The retropubic approach allows simultaneous node dissection and removal of prostate glands, although the length of hospitalization and immediate postoperative morbidity are higher in our institution. The robotically assisted laparoscopic approach allows some improvement in visualization compared to the retropubic or laparoscopic surgeries due to the magnification and three-dimensional visualization, but it has yet to show any significant advantages in terms of operative morbidity, length of stay, or reduction in long-term morbidity. There are few if any large comparisons with radical perineal prostatectomy, although results to date indicate that no significant differences exist.

Alternatives to radical prostatectomy include observation, active surveillance (AS), hormonal deprivation, and radiation therapy. Although we do not consider either observation or hormonal deprivation to be curative, these are good options only for patients with less than a 5-year life expectancy, patients who are >70 years old with a well-differentiated cancer, and patients who are at high risk for surgery and refuse radiation. Radiation therapy, however, may be definitive and has a 5- to 10-year survival rate equivalent to that of surgery. The recurrence rates with radiation therapy are bimodal, with initial recurrences within 1 to 2 years of treatment and a delayed peak at 5 to 7 years after treatment. The recognition that many low-risk cancers (low volume 3/3 Gleason grade) have a minimal risk of prostate cancer death or progression has led to the introduction of AS for many patients who would previously have chosen intervention. If the patient is young with a 15-year or longer outlook and has significant disease, we feel that our results would favor radical prostatectomy.

SURGICAL TECHNIQUE

The patient is placed in an exaggerated lithotomy position (Fig. 32.1). It is important that the patient's perineum be parallel to the floor because this directly affects exposure. We use a standard operating room table with seven folded sheets under the patient's sacrum supporting the patient's entire weight. Shoulder braces are not recommended, and if a patient tends to slide off the sheets, we will place the table in a slight reverse Trendelenburg position. The patient's legs are stabilized using candy cane or Allen stirrups, again taking precautions to prevent stretching the hamstring or causing pressure on the legs. Prior to putting the patient in position, the legs are wrapped with ACE bandages.

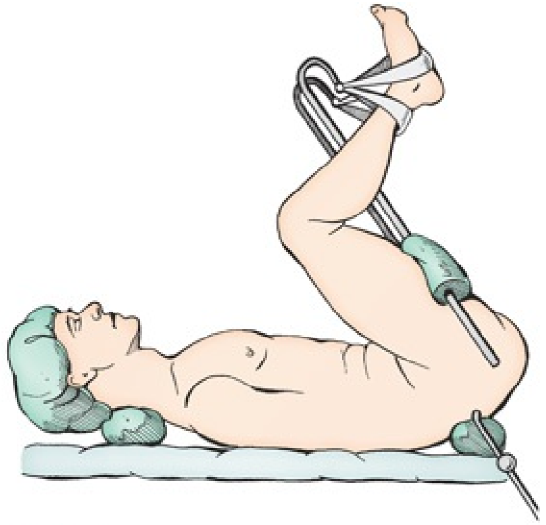

FIGURE 32.1 Positioning of the patient requires the perineum to be parallel to the floor. The sacrum supports the patient's weight, and the legs are positioned with no traction on the hamstrings. No shoulder braces are indicated.

Four instruments are significant in assisting the surgeon for this operation. These include the Lowsley curved tractor, the Young straight prostatic tractor, a Halogen head lamp, and an Omni-Tract Mini Wishbone retractor system. The curved Lowsley tractor is used to bring the prostate up into the perineum to allow dissection against the prostate while mobilizing the rectum from the prostate. The straight Young tractor is used to manipulate the prostate laterally as well as cephalad and caudad after the membranous urethra has been divided. The Halogen head lamp is important because it allows the surgeon to aim a strong light into the operative field, which may be too deep and narrow for standard operating lights to adequately illuminate the structures. The Omni-Tract Mini Wishbone allows virtually unlimited retraction in any direction. We have developed a posterior weighted speculum that is compatible with the Omni-Tract (Fig. 32.2). A further option is the harmonic scalpel, which allows coagulation and closure of vessels without transmission of electrical current, thereby reducing the risks to the neurovascular bundles.

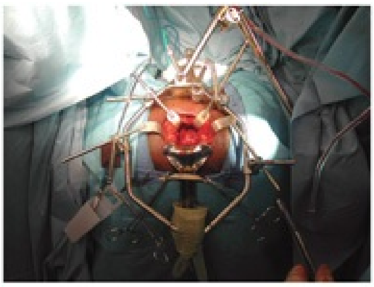

FIGURE 32.2 Mini Wishbone retractor set up for perineal prostatectomy.

It should be noted that in manipulating the prostate within the pelvis, the pelvis should be viewed as a cone with the apex of the cone being the incision (Fig. 32.3). To achieve better visualization, it is sometimes necessary to actually push the prostate further into the pelvis. Also note that traction is not placed directly on the bulb or membranous urethra, as this will decrease the likelihood of restoration of potency and potentially affect the patient’s continence postoperatively.

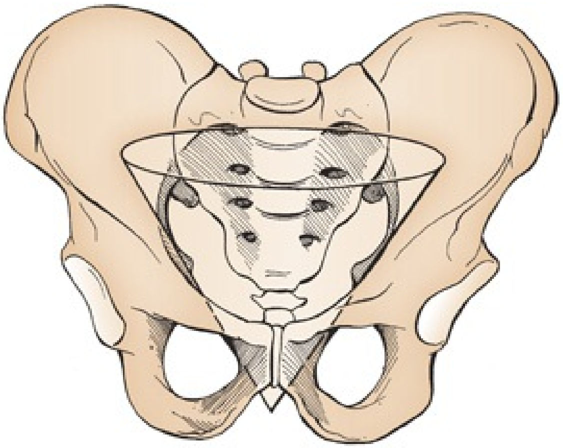

FIGURE 32.3 The bony pelvis is a cone with the apex at the incision. Better visualization can be obtained in many cases by actually pushing the prostate deeper into the pelvis.

The incision is made from the ischial tuberosity crossing the midline at the juncture between the squamous epithelium and the mucocutaneous border of the rectum (Fig. 32.4). The incision extends posteriorly to a line equal to the posterior portion of the anus. Using sharp dissection and electrocautery, the ischiorectal fossae are entered, and using blunt dissection, the central perineal tendon is identified and transected with electrocautery. At this point, we employ the Belt approach, dissecting down to the white fascia of the rectum and proceeding subsphincterically (Fig. 32.5). A transsphincteric or suprasphincteric approach is also an option. Using predominantly careful dissection with an index finger in the rectum, the rectal sphincter and levator ani sling can be dissected free of the rectum with minimal bleeding (Fig. 32.6). The blades from the Mini Wishbone retractor are then used to retract these muscles anteriorly and laterally. With tension on these muscles and tension on the rectum, the rectourethralis is identified and divided, allowing the surgeon to dissect the rectum free of the apex of the prostate (Fig. 32.7). The assistant presses down on the handle of the Lowsley curved tractor, which elevates the prostate into the wound and facilitates mobilization of the rectum off the prostate.

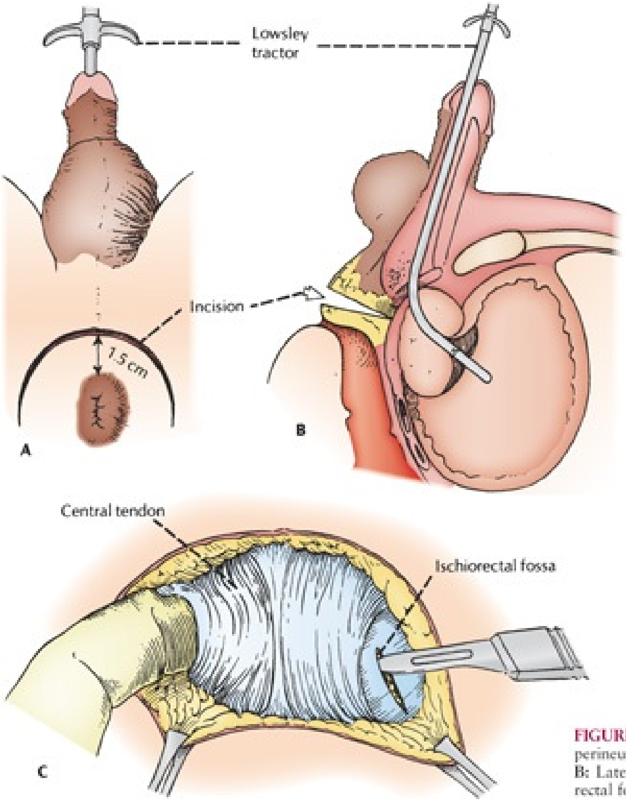

FIGURE 32.4 A: An inverted U-shaped incision is made in the perineum extending from one ischial tuberosity to the other. B: Lateral view of incision. C: Access is gained to the ischiorectal fossa bilaterally and the central tendon is divided.

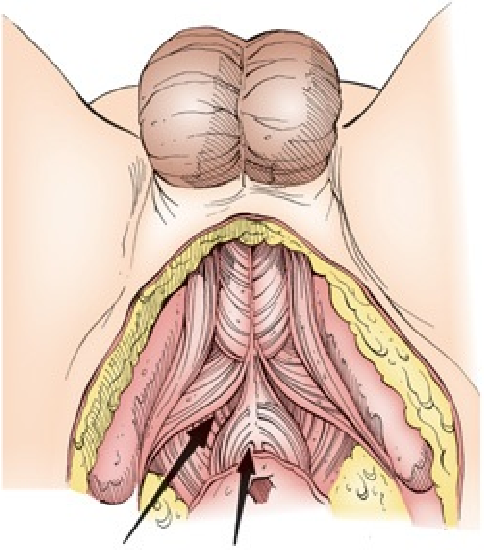

FIGURE 32.5 The dissection is carried along the rectal fascia (*lateral arrow*), sparing the anal sphincter (*mid arrow*).

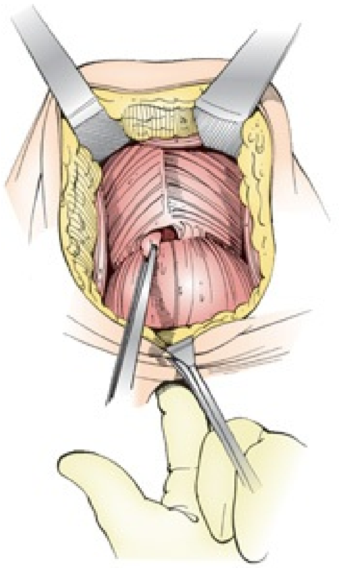

FIGURE 32.6 The levator ani and the anal sphincter are retracted to expose the rectourethralis.

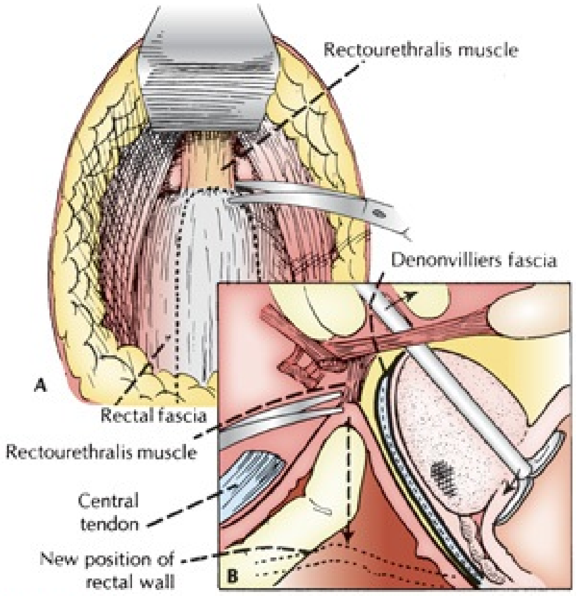

FIGURE 32.7 Dissection of the rectum from the prostate after division of the rectourethralis is facilitated with the surgeon's finger in the rectum.

In patients who are undergoing nerve-sparing surgery, the dissection is carried down to approximately 1.5 to 2.0 cm from the apex, at which point the external layer of the Denonvilliers fascia is divided and dissection is carried between the two layers of the Denonvilliers fascia (Fig. 32.8). Care is taken not to damage the neurovascular bundles that course along the lateral posterior prostate on either side (Fig. 32.9).

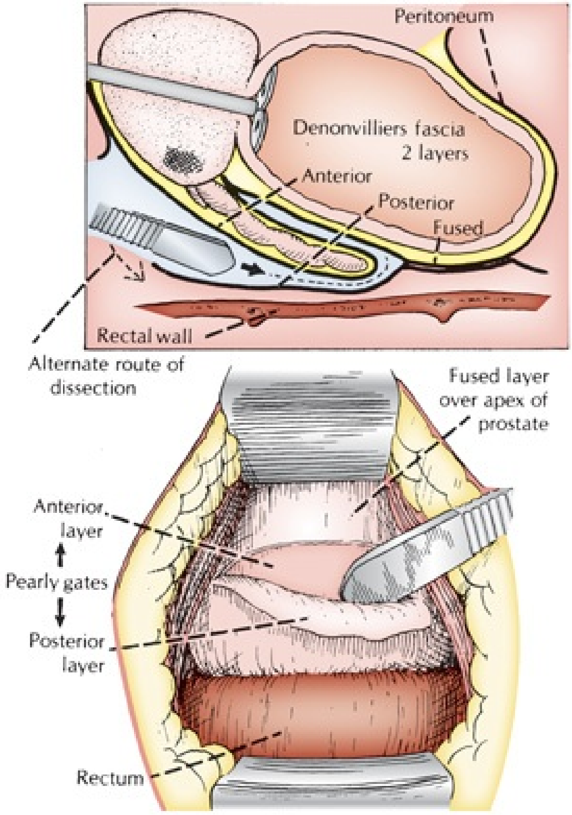

FIGURE 32.8 An incision into the posterior layer of the Denonvilliers fascia allows the dissection to continue between the two layers. For a nerve-sparing technique, this incision is made transversely 1 to 2 cm proximal to the apex of the prostate, avoiding carrying the incision into the neurovascular bundles.

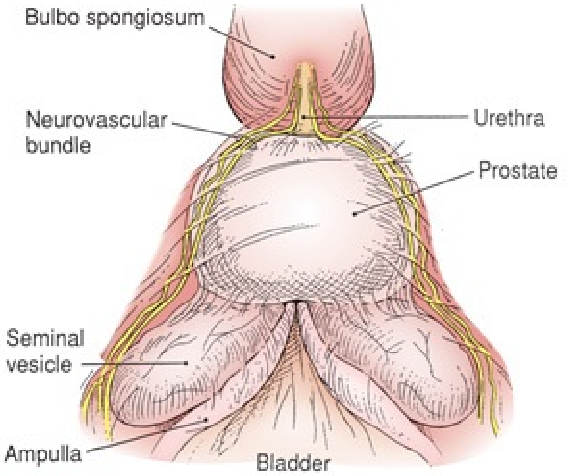

FIGURE 32.9 Anatomic view of the neurovascular bundles from the posterior view of the prostate. The vessels course along the lateral and posterior prostate and cross the apex to enter the urogenital diaphragm posterior to the membranous urethra.

The distal portion of the Denonvilliers fascia is then incised in the midline with scissors, and the tag is used to facilitate dissection of the neurovascular bundle from the prostate (Fig. 32.10); the inferior pedicle, if present, is then ligated and divided (Fig. 32.11). If the dissection is in any way impaired by fibrosis such that there is a potential for prostatic tissue to be left behind, the neurovascular bundle is sacrificed on that side.

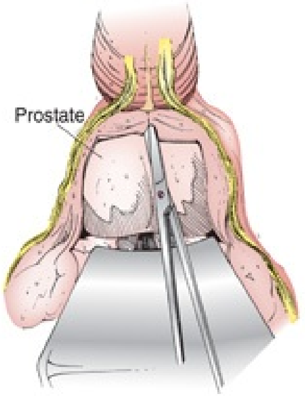

FIGURE 32.10 Incision of the distal posterior layer of the Denonvilliers fascia in the midline. This is best done *without* electrocautery if a nerve-sparing technique is planned.

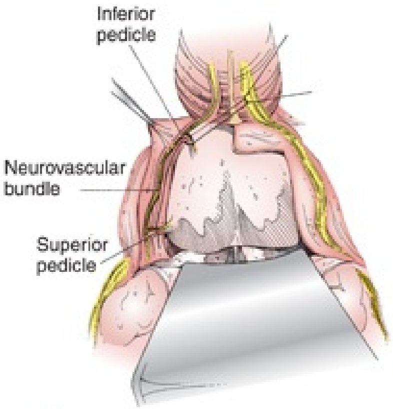

FIGURE 32.11 Using the wings of the distal posterior layer of the Denonvilliers fascia to aid in dissection, the inferior branch from the neurovascular is isolated and divided.

It should be noted during this dissection that the neurovascular bundle actually courses across the posterior surface of the prostate at the apex and enters the urogenital diaphragm just posterior to the membranous urethra. This proximity is important in that the vesicourethral anastomosis may incorporate the neurovascular bundle if the surgeon is not precise with the placement of sutures in the posterior urethra. Very gentle and careful retraction of the neurovascular bundle on either side thereby exposes the proximal membranous urethra for placement of such sutures during urethrovesical anastomosis.

A right-angle clamp is placed around the membranous urethra and generally meets little resistance if one stays posterior to the endopelvic fascia (Fig. 32.12). The Lowsley tractor is removed and the membranous urethra divided. The Young tractor is then placed into the bladder through the prostatic urethra, and the endopelvic fascia can be pushed away superiorly or divided with the harmonic scalpel.

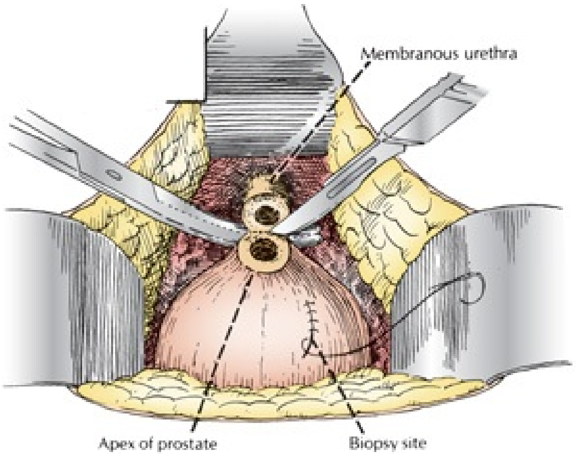

FIGURE 32.12 Division of the membranous urethra at the apex of the prostate.

The anterior prostate is dissected free of the bladder (Fig. 32.13). It should be noted that there are generally two small arteries that enter the prostate along the anterior bladder at 10 and 2 o'clock positions that should be cauterized and divided. The groove between the prostate and bladder is identified, and the prostate and bladder can be separated with either sharp or blunt dissection. If the plane between the prostate and bladder is not easily developed, the dissection should be performed sharply and biopsies taken of the bladder neck to ensure that there is no invasion of the bladder neck by the cancer. In patients who have had prior transurethral resections of the prostate, palpation of the blades of the Young tractor can be used to identify the bladder neck. Care should be taken during the anterior dissection because this is a common area for a positive margin.

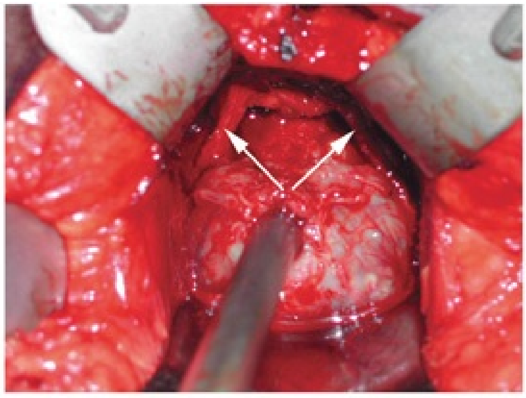

FIGURE 32.13 Urethra divided and anterior prostate demonstrated with neurovascular bundles mobilized (*arrows*).

In most cases, there is insignificant bleeding from the dorsal venous complex in the endopelvic fascia. However, if there should be communicating veins, they may be suture-ligated using 3-0 Vicryl. The prostate is dissected from the bladder anteriorly to posteriorly to the 5 and 7 o'clock positions, respectively, on the patient's left and right, and the bladder neck is divided over the Young tractor prior to removal of the Young tractor; a stay suture may be inserted in the bladder neck at this point and a Penrose drain can be inserted through the vesicostomy and passed through the Young tractor blades and then brought out the prostatic urethra while removing the young tractor thus establishing through and through traction on the prostate (Fig. 32.14). The bladder is evacuated of any urine, and the posterior bladder neck is divided. The prostate is then dissected free from the posterior bladder. A plane is entered after dividing the posterior bladder neck, which is anterior to the seminal vesicles and the ampulla of the vas but posterior to the bladder. The superior pedicles lie in the lateral aspect of this plane and can be divided. At this point, a median lobe can be encountered. The mucosa can be divided on the bladder side of the lobe and the lobe mobilized with the prostate to identify the true bladder neck. Care is necessary to avoid ureteric damage.

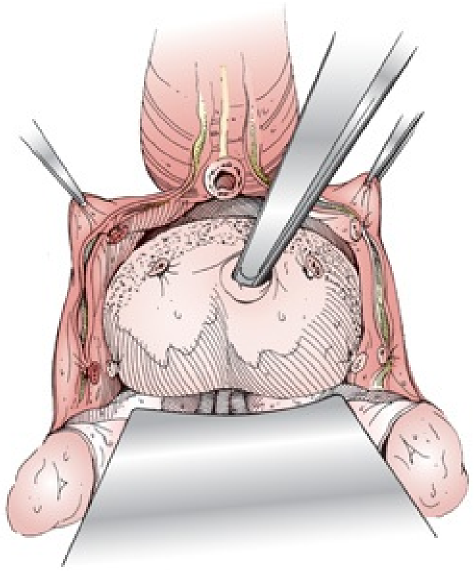

FIGURE 32.14 A Young prostatic tractor is used to manipulate the prostate and to identify the vesical neck.

Attention is then directed to the posterior surface of the prostate. The rectum is swept free of the neurovascular bundles, which also allows identification of the superior pedicles of the prostate as well as the seminal vesicles. The superior pedicles can be divided with the harmonic scalpel at this point, if not done earlier. The seminal vesicles are dissected to their tips with blunt dissection, and the artery from the seminal vesical is divided by clips or harmonic scalpel. The vasa deferens are likewise divided. Any remaining fibrolymphatic tissue is then divided, allowing removal of the prostate.

After ensuring complete hemostasis, the bladder neck may be reconstructed if necessary using 3-0 Vicryl on an SH needle beginning posteriorly to anteriorly (Fig. 32.15). This direction of the closure, beginning in the posterior bladder, is done to facilitate the closure without injury to the ureters and also to take advantage of the anatomic relationship between the bladder neck and the membranous urethra with a shorter distance being anteriorly. The anastomosis is performed using 3-0 Vicryl simple sutures and an RB-1 controlled-release needle (Fig. 32.16). The anastomosis is performed around a 20Fr, 10-mL Silastic catheter, and generally seven to eight sutures are used. Care should be taken that the membranous urethra is clearly identified and the neuromuscular bundle is not incorporated in the anastomosis. The continence mechanism should be left undisturbed. These measures will contribute to potency and continence.

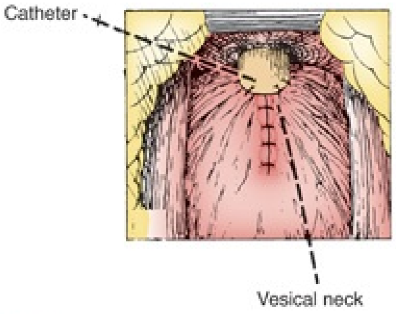

FIGURE 32.15 Reconstruction of the posterior bladder neck is carried from posterior to anterior, leaving an opening of approximately 22Fr.

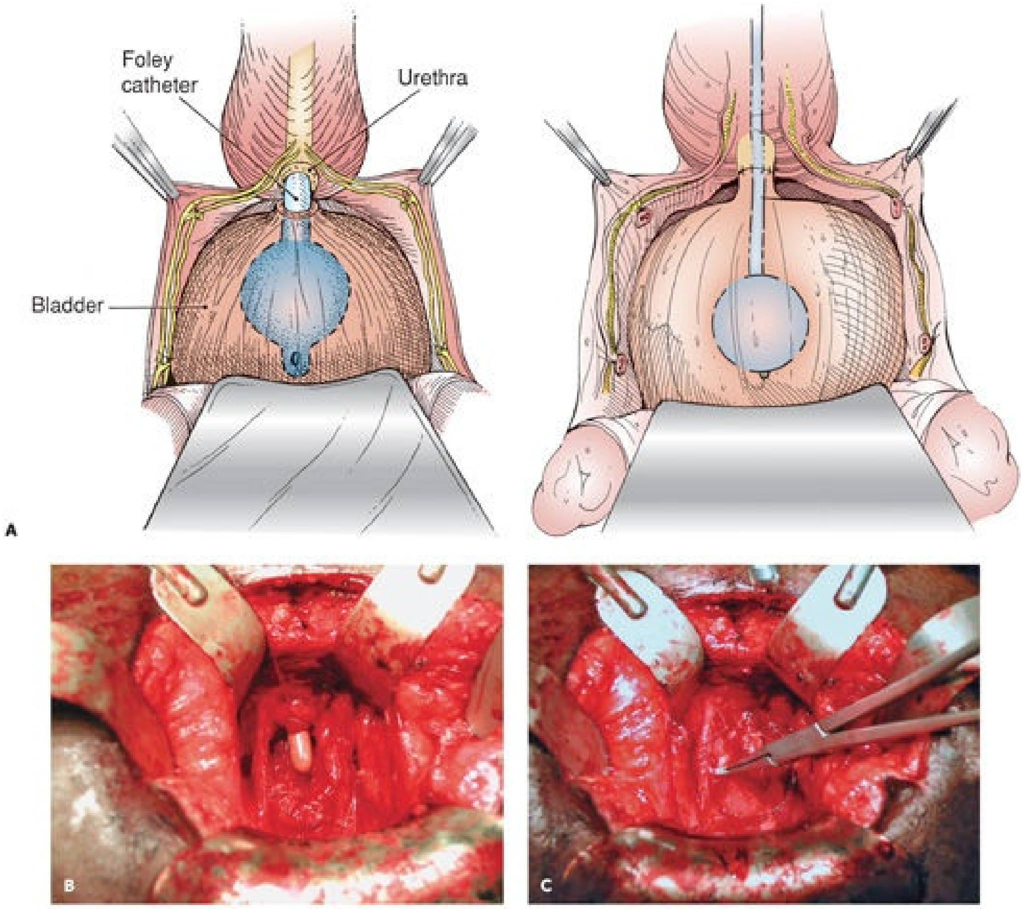

FIGURE 32.16 A: Anastomosis of the urethra to the bladder is performed over a 22Fr Foley catheter. B: Anastomosis of urethra to bladder neck with preserved neurovascular bundles. C: Completed anastomosis of bladder to urethra with intact right neurovascular bundle demonstrated.

The rectum is then inspected, the Foley balloon inflated, and a Penrose drain placed in the left ischiorectal fossa and brought to the skin either out the lower end of the wound or through a separate stab incision. The incision is closed with a 3-0 Vicryl to the deep layers and 0 chromic for the skin. One or two sutures are placed to reapproximate the central tendon, and the remainder of the sutures is used to close the skin in a horizontal mattress fashion (Fig. 32.17).

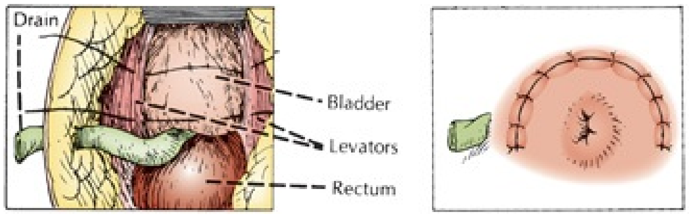

FIGURE 32.17 Closure of the incision.

Postoperatively, patients have a very low requirement for pain medication. Most patients either do not require parental pain medication or are off the parental medications within 12 to 24 hours. Average time to discharge is less than 24 hours from the time of surgery (Table 32.1). The patient’s catheter is removed on day 7 to 8. The Penrose drain is removed prior to discharge.

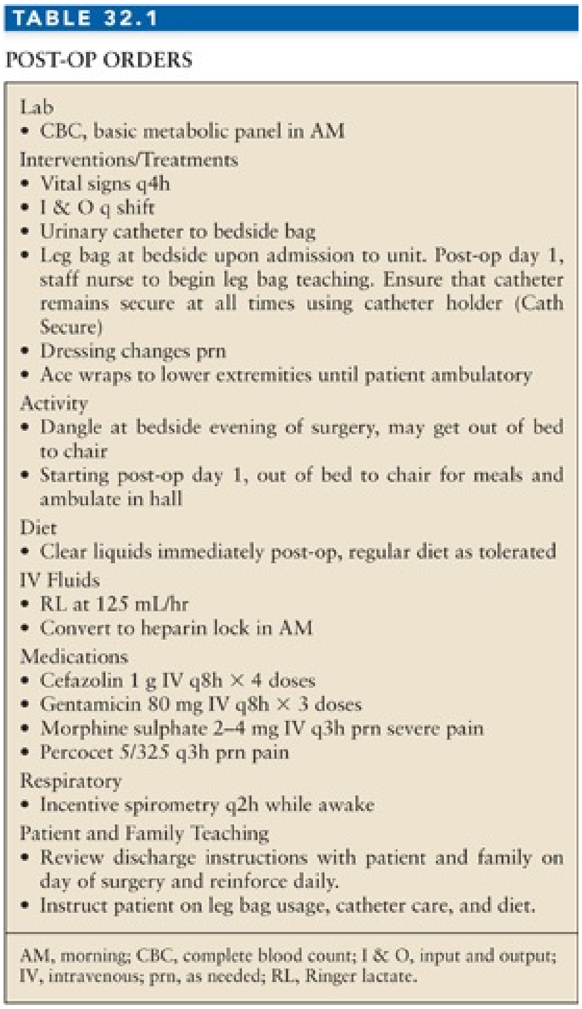

TABLE 32.1

POST-OP ORDERS

Lab
- CBC, basic metabolic panel in AM

Interventions/Treatments
- Vital signs q4h
- I & O q shift
- Urinary catheter to bedside bag
- Leg bag at bedside upon admission to unit. Post-op day 1, staff nurse to begin leg bag teaching. Ensure that catheter remains secure at all times using catheter holder (Cath Secure)
- Dressing changes prn
- Ace wraps to lower extremities until patient ambulatory

Activity
- Dangle at bedside evening of surgery, may get out of bed to chair
- Starting post-op day 1, out of bed to chair for meals and ambulate in hall

Diet
- Clear liquids immediately post-op, regular diet as tolerated

IV Fluids
- RL at 125 mL/hr
- Convert to heparin lock in AM

Medications
- Cefazolin 1 g IV q8h × 4 doses
- Gentamicin 80 mg IV q8h × 3 doses
- Morphine sulphate 2–4 mg IV q3h prn severe pain
- Percocet 5/325 q3h prn pain

Respiratory
- Incentive spirometry q2h while awake

Patient and Family Teaching
- Review discharge instructions with patient and family on day of surgery and reinforce daily.
- Instruct patient on leg bag usage, catheter care, and diet.

AM, morning; CBC, complete blood count; I & O, input and output; IV, intravenous; prn, as needed; RL, Ringer lactate.

OUTCOMES

Complications

Perioperative complications include hemorrhage, wound infection, cardiovascular complications, and rectal injury. The instance of rectal injury is <1% with current techniques and antibiotics or preoperative bowel preparation (two Fleet enemas, the night before and morning of surgery). The rectal injury is closed primarily in two layers without the need to perform a diverting colostomy. Wound infection rates are <1%, and cardiovascular complications are approximately 1% to 2%. The average blood loss in these patients is approximately 300 to 400 mL, and our transfusion rate is <1%. Deep venous thrombosis is extremely uncommon.

Long-term complications include incontinence and impotence. Incontinence requiring intervention such as pads, clamps, or inflatable devices occurs in 2.8% of patients. We have found that incontinence generally occurs in patients who are older, obese, and have had prior radiation therapy. Potency following nerve-sparing perineal prostatectomy is dependent upon the patient’s age and preoperative status. Patients under the age of 60 who are fully potent and have both neurovascular bundles spared have approximately a 60% to 70% potency rate. Patients who are over the age of 60 have a reduced rate of potency (~40% to 50%), and we have only had 5% to 10% of patients over the age of 70 who have spontaneously regained potency. Patients who are having difficulties with potency prior to surgery and patients in whom the neurovascular bundles could not be spared will likely be impotent. We generally advocate early use of pharmacotherapy and vacuum erection device or other means of assistance in these patients.

Results

Following radical prostatectomy, recurrence can be measured using PSA, which is exquisitely sensitive. Any patient who undergoes a radical prostatectomy can expect his PSA to fall below detectable levels (less than 0.1 ng per mL). Failure to do so generally means that the patient has significant residual disease, either locally or distantly. Another group of patients will have an initial drop of their PSA to undetectable levels and then a return to measurable levels. These patients may have local and/or distant recurrence of their disease, or possibly residual malignancy (6). Occasionally, the PSA will rise to between 0.1 and 0.2 and then stabilize again. Generally, we do not use salvage radiation therapy until the PSA has risen over 0.2 ng per mL. Additionally, if the PSA is going to rise, it will do so within 2 years in 90% of patients and within 4 years in virtually every patient. Based on PSA, we can now predict disease recurrence earlier, and depending on the PSA doubling time, we can identify those patients with higher risk recurrence who require urgent aggressive intervention.

Using this technique and a clinical care pathway, we have seen better pain control, earlier ambulation, quicker short-term recovery, and earlier discharge at considerably lower cost than in patients undergoing any other form of radical prostatectomy. This has been confirmed in other studies and will lead to a lower cost of care (2,7).

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CHAPTER 33 ROBOTICALLY ASSISTED LAPAROSCOPIC RADICAL PROSTATECTOMY

SANDIP M. PRASAD, DAVID GILLATT, AND MAGNUS ANNERSTEDT

Until the past two decades, radical prostatectomy for clinically localized prostate cancer was traditionally performed through a retropubic or perineal approach. Since the first reported laparoscopic radical prostatectomy (LRP) performed by Schuessler and colleagues (1) in 1997, the use of this minimally invasive approach gained favor in certain centers for the reported improvements in perioperative outcomes including blood loss and length of stay with similar functional and oncologic outcomes in high-volume centers (2). However, the technical challenges associated with this approach, including intracorporeal suturing of the vesicourethral anastomosis, limited range of motion, and two-dimensional optics, limited its widespread adoption to skilled laparoscopists.

One decade following the first LRP, Abbou and colleagues (3) first reported the use of a robotic system to perform the critical steps of radical prostatectomy in 2001. They used the da Vinci surgical system, which remains to this day the only commercially available surgical robot used for radical prostatectomy. Since that time, robotically assisted laparoscopic radical prostatectomy (RALP) has become the standard of care for radical prostate cancer surgery in most western countries accounting for the majority of all such procedures.

The aim of this chapter is to describe the use of the da Vinci surgical system to deliver RALP and to outline some of its potential advantages and pitfalls.

BENEFITS OF ROBOTIC-ASSISTED SURGERY

The da Vinci system is a precise master-slave surgical assistance device with high-quality, three-dimensional, magnified optics. It offers the surgeon the opportunity to operate in narrow spaces with difficult access through the use of three (in earlier generations) and four multijointed robotic arms. In addition, the robotic platform offers the surgeon the additional benefits of motion scaling to allow precise dissection and tremor filtration to facilitate delicate movements (4). The instrumentation articulates about a “wrist” allowing 7 degrees of movement exceeding that of the human wrist. It is particularly effective for difficult dissection and for suturing in tight spaces.

INDICATIONS FOR SURGERY

The indications for RALP are the same as those for open or laparoscopic approaches. Patients should have clinically localized prostate cancer and a life expectancy exceeding 10 years. As experience with RALP has grown, previously stated contraindications such as prior abdominal surgery and obesity are rarely an obstacle to performing RALP with reasonable short- and long-term outcomes in the hands of experienced surgeons (5,6).

PREPARATION

Standard preoperative assessment is appropriate, including a type and screen. Blood products are uncommonly administered given the low rate of blood transfusion with RALP (7). We use a clear liquid diet the day before surgery and a mild mechanical bowel prep the evening prior to surgery. Some surgeons use a preoperative enema to cleanse the rectum; however, in our practices, this is only employed in those undergoing salvage surgery postradiation given the increased rate of rectal laceration in these patients (8).

On the morning of surgery, patients receive perioperative antibiotic prophylaxis with a cephalosporin and deep venous thrombosis prophylaxis with subcutaneous heparin and sequential pneumatic compression devices prior to induction per AUA recommendations (9,10).

ANESTHETIC CONSIDERATIONS

General anesthesia is essential for this operation. The patient requires relaxation and will be positioned in extreme Trendelenburg for a prolonged period. This position, coupled with pneumoperitoneum, may produce cardiopulmonary derangements in certain patients. In addition, a history of glaucoma or intracranial pathology such as arteriovenous malformation or cerebral aneurysm should be reviewed, as this position results in increased intraocular pressure and cerebral blood volume (11,12). Typically, an arterial line or central venous access is not routinely needed except in selected patients at higher risk of complication. In addition, to avoid periorbital and laryngeal edema, judicious fluid administration should be delivered while the patient is in Trendelenburg position (13).

SURGICAL TEAM

The surgical team is composed of one surgeon at the robotic console and one bedside assistant. To facilitate efficiencies in preparation for and performance during robotic surgery, we endorse the use of a dedicated “robot team” for nursing and surgical assistants.

POSITIONING

The patient is positioned in a lithotomy position with the arms tucked. The operating table needs to allow the legs to be separated and the hips to be flexed/extended. It should allow Trendelenburg positioning. The hips should be slightly flexed and the thighs supported to reduce stress on the anterior thigh muscles. The legs should be bandaged to the leg supports in order to fix their position. Once the ports are in place, the patient will be tilted into Trendelenburg to an angle of approximately 30 degrees. The legs may then be brought downward by extension at the hip to allow access for the da Vinci robot between the legs. At all times, care must be taken to avoid tension on the thigh muscles and any excess pressure on calves and thighs. Positioning injuries, although uncommon, can lead both to nerve impairment and rhabdomyolysis (14,15). Once the patient is prepped and draped, an 18Fr Foley catheter is placed sterilely on the field.

PORT PLACEMENT AND DOCKING

Pneumoperitoneum is obtained by surgeon preference; we employ the Veress needle through the anticipated camera port immediately cranially or inferiorly to the umbilicus. Pneumoperitoneum is established to 15 mm Hg with CO_2. The 12-mm camera port is then introduced directly through this incision and then the 0-degree camera (used for the entire case) is passed into the peritoneum and accessibility including the presence of adhesions is assessed. In the setting of prior upper abdominal surgery or umbilical hernia repair, we use an optical trocar or the open Hasson technique to gain access into the peritoneum.

The anticipated location of each port is infiltrated with local anesthetic without epinephrine. All ports are then placed under direct vision, with laparoscopic adhesiolysis performed as needed to facilitate port placement. Three 8-mm da Vinci reusable ports are then placed. Two are positioned laterally 8 to 10 cm from either side of the midline just below the camera port and the third laterally approximately 8 cm from the medial robotic port at least two fingerbreadths above the anterior superior iliac spine (ASIS). The right-handed robotic port will house the scissors/shears; the left-handed robotic port uses the bipolar forceps (fenestrated or Maryland); and the third robotic port exclusively uses the ProGrasp forceps. This third arm is placed on the right or left side of the patient per surgeon preference. It is critical that the ports are separated by a minimum of 8 cm so that the da Vinci arms do not clash outside the patient during the procedure.

In addition, two conventional laparoscopic assistant ports are placed on the opposite side to the third arm. A 12-mm port is placed laterally, at least 2 cm anterior and superior to the ASIS, and a 5-mm port is placed above and just medial to the medial robotic port below the costal margin. These ports are used for retraction, suction, introduction of sutures, and other laparoscopic assistance by the bedside assistant.

Prior to docking, the patient is placed in extreme Trendelenburg at an angle of approximately 30 degrees and the legs are dropped by extending the stirrups at the hip joints. Once the ports are in position, the da Vinci system should be guided over the patient's abdomen by being driven in a straight line between the patient's legs. When the central arm is over the camera port in the "sweet spot," the four da Vinci arms can be positioned and locked on to their respective ports. The camera and its port are positioned to view the lower abdomen and pelvis. The instruments are inserted under vision and locked into their respective ports.

With experience, the steps from Veress insertion to docking the robot can be achieved in less than 15 minutes.

THE OPERATION

There are two traditional surgical approaches to RALP—the "anterior" and "posterior" approach. This specifically refers to the approach for dissection of the vasa and seminal vesicles (SV). If the posterior approach is employed, this is the first step in the procedure and is described in the following text. In the anterior approach, dissection of the seminal vesicles is performed following division of the posterior bladder neck. If indicated, we also advocate performing pelvic lymph node dissection (PLND) prior to beginning radical prostatectomy, as the therapeutic benefit of prostatectomy is unknown in the setting of positive regional lymph nodes.

Dissection of the Vasa and Seminal Vesicles (Posterior Approach Only)

Adhesions of the large and small bowel to the lateral pelvic side walls are common and adhesiolysis is performed to allow for exposure of the planned PLND and for allowing mobilization of the sigmoid colon out of the pelvis. The peritoneum overlying the vas deferens is divided in the pouch of Douglas 3 to 4 mm above the insertion of the sigmoid colon into the posterior peritoneum. Once the vas is identified, it is dissected to the base of the prostate and laterally to an anatomic "bend" that can be visualized at the lateral edges of the posterior peritoneum overlying the pouch of Douglas and then divided laterally. Once the vas is freed, it is retracted anteriorly and the SV can be identified posteriorly. Dissection of the SV occurs in a medial to lateral direction posteriorly, with a combination of sharp and blunt cold dissection to free the SV from surrounding tissues. Hem-O-Lok clips can be used to isolate and divide perforating arteries that are present posteriorly and at the tip of the SV. This process is repeated on the other side and once the vasa and SVs are divided, they are retracted anteriorly. Denonvilliers fascia is then visible under these structures and can be sharply incised just below the SVs and a plane can be developed using sharp and blunt dissection posterior to the prostate up to the apex. Some surgeons will choose to start this plane and then complete the posterior dissection following bladder neck division, but the entire posterior dissection to the prostatic apex can be performed at this time.

Bilateral Pelvic Lymph Node Dissection (If Indicated)

The standard PLND boundaries are the bifurcation of the common iliac artery proximally, the node of Cloquet posteriorly, the bladder medially, the obturator nerve posteriorly, and the pelvic side wall laterally. The fourth arm is used to mobilize the sigmoid colon to the contralateral side of PLND to visualize the bifurcation of the common iliac artery. The peritoneum is divided along the visualized path of the external iliac artery from the bifurcation of the common iliac artery to the internal inguinal ring. The lateral aspect of the lymph node package is developed by opening the fibroadipose tissue from the anterior and medial surface of external iliac vein until the pelvic side wall is identified. We find this easiest at the level of the pubis where the obturator nerve can be identified and then carried out proximally.

The medial aspect of the PLND is then performed by grasping the obliterated umbilical artery and retracting it medially. There is a fibroalveolar plane lateral to the bladder that can be carried bluntly to the obturator nerve. Once the obturator nerve is identified, the closed scissors is used to bluntly and gently strip nodal tissue off the nerve along the entire length of the nodal packet. The lymph node packet is then divided distally beyond the node of Cloquet. Clips or bipolar energy are recommended for larger lymphatic vessels to avoid postoperative lymphatic leak. Anterior retraction of the packet facilitates proximal dissection to the iliac artery bifurcation. Lymph nodes are placed into a 10-mm laparoscopic specimen retrieval bag and removed through the assistant 12-mm port. We do not routinely send frozen sections unless there is high clinical suspicion intraoperatively or by preoperative imaging.

Mobilizing the Bladder

The scissors are used to incise the medial umbilical ligaments up to the anterior abdominal wall (Fig. 33.1). The incision is made by using the outer part of the blades of the monopolar scissors. The tips of the scissors then incise the peritoneum on each side from each medial umbilical ligament to the ipsilateral vas deferens, which can be divided or left in situ per surgeon preference. To open the lateral space of Retzius, both right- and left-sided instruments are used to part the bladder from its attachments to the pelvic side wall in a “breaststroke” motion and this blunt dissection should continue under the pubic bone until the endopelvic fascia is exposed. This process should happen one side at a time. The two incisions in the medial umbilical ligaments can then be joined by similar monopolar and bipolar dissection continued anteriorly above the bladder, dropping it away from the anterior abdominal wall until the prostate and dorsal vein complex (DVC) are identified.

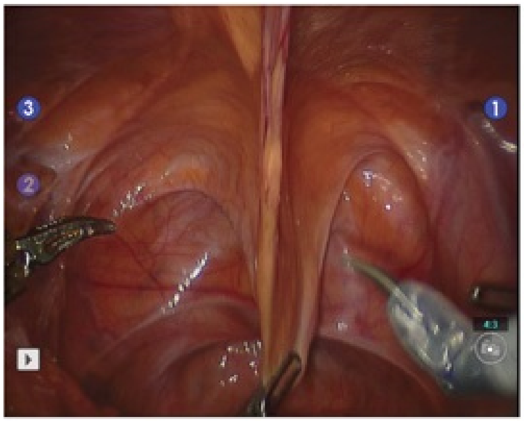

FIGURE 33.1 The robotic fourth arm grasping the right medial umbilical ligament

Exposure of the Prostatic Apex

The fourth arm is used to pull the urachus toward the patient's head, facilitating exposure of the prostatic apex. By blunt dissection, the fat lying over the anterior prostate should be swept away cauterizing any vessels entering laterally. The fat can be sent for histology in the setting of high-risk disease. The endopelvic fascia is opened by making a small incision lateral to the mid part of the prostate. This is extended cranially lateral to the bladder neck and caudally to the puboprostatic ligaments to expose the apex of the prostate (Fig. 33.2). Care should be taken at the apical end of the incision to avoid opening vessels either in or adjacent to the DVC. Once the fascia is incised, blunt dissection with the bipolar forceps can sweep the levator muscles away from the prostate, exposing the DVC and the prostatic apex and urethra. Occasionally, partial division of the puboprostatic ligaments helps to visualize the junction between urethra and DVC if needed.

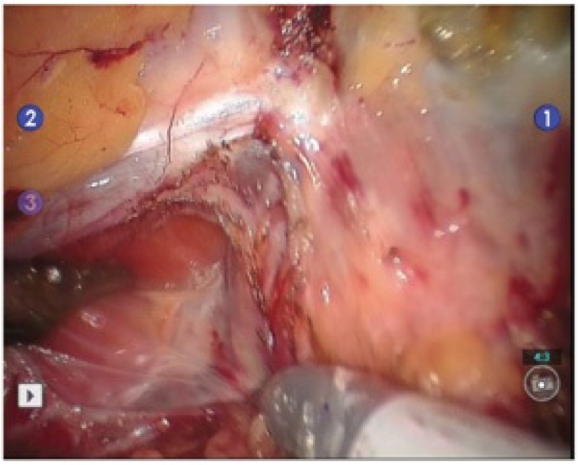

FIGURE 33.2 Incision of the endopelvic fascia

Ligation of the Dorsal Vein Complex

It is debatable as to whether the DVC should be ligated at this point. It is possible that by not ligating the DVC and dividing it sharply later in the procedure, a more accurate apical dissection will reduce the risk of positive margins at this site. However, we prefer to suture ligate the DVC at this time. This can be achieved by using a 0-Vicryl suture on a CT-1 needle measured to 10 inches. We begin DVC ligation by passing the needle medial to lateral through the apex of the right puboprostatic ligament. The suture is then passed horizontally 2 cm distally from the prostatic apex from right to left in the notch between the DVC and urethra (Fig. 33.3). The suture is then passed through the left puboprostatic ligament from left to right and the suture is then tied with a slip knot to secure the DVC. Securing the DVC stitch to the apex of each puboprostatic ligament ensures that the knot is tied distally and is unlikely to be inadvertently divided with the dorsal vein. We then perform a "back-bleeder" stitch with the remaining suture, placing the needle midway between the apex and base of the prostate between each cut edge of the endopelvic fascia.

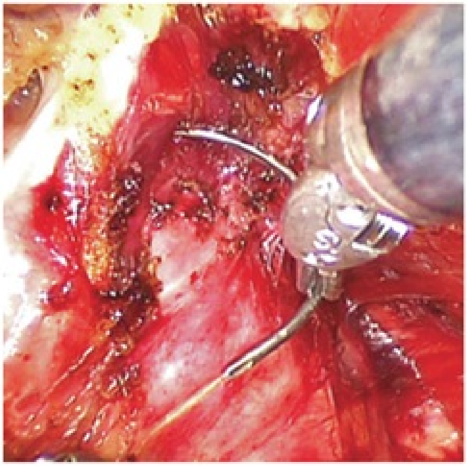

FIGURE 33.3 Distal placement of the dorsal vein ligation suture

Stapling of the DVC has been described, but we believe that this may limit the ability to perform more accurate apical dissection later in surgery.

Bladder Neck Dissection

At this time, some surgeons prefer to change the camera to a 30-degree lens in a downward orientation, although the procedure can be continued without significant challenges using the 0-degree camera. The anterior bladder neck is identified through a series of visual cues (Fig. 33.4): (a) asking the assistant to put gentle traction on the urethral catheter to "bounce" the balloon at the bladder neck; (b) identifying the area where loose fat cannot be bluntly dissected off the prostate; and (c) identifying the prostatovesical junction laterally where the endopelvic fascia has been opened. These maneuvers (in addition with preoperative magnetic resonance imaging [MRI], when available) may also suggest the presence of a median lobe. The anterior bladder is incised horizontally with diathermy until the bladder is entered (Fig. 33.5). The urethral catheter balloon is deflated and the catheter pulled out of the bladder defect. The ProGrasp forceps (third arm) or the assistant can grab the catheter by its "eye" and pull it up toward the anterior abdominal wall. The assistant can then apply traction to the catheter outside the body putting the bladder neck under traction and exposing the posterior bladder neck. At this point, the ureteric orifices can be identified and avoided. The posterior bladder neck can now be incised. However, there are two situations that may make this part of the operation tricky and demand particular attention at this point of the surgery:

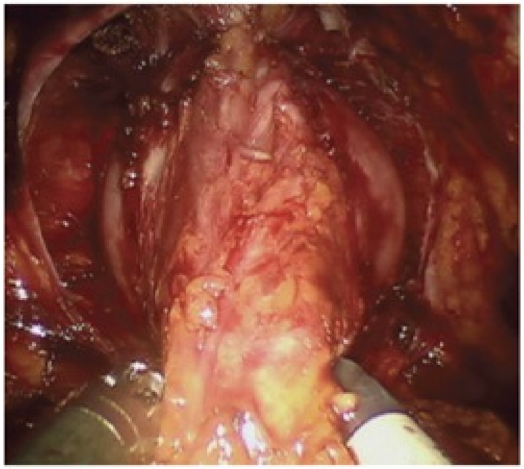

FIGURE 33.4 "Pinching" the bladder to identify the prostatovesical junction laterally

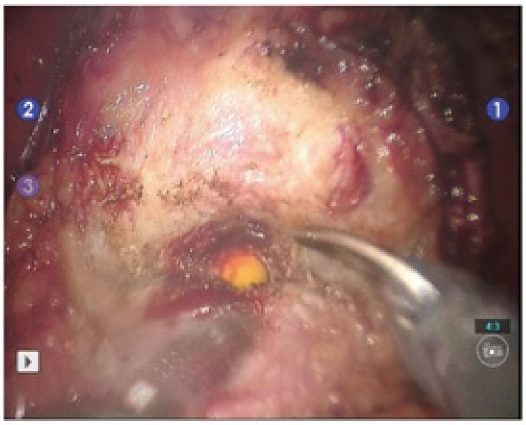

FIGURE 33.5 Incision of the anterior bladder neck, revealing the urethral catheter intravesically

1. Previous transurethral prostatectomy: The scarring left by surgery may make the ideal place to incise the posterior bladder neck difficult to judge. In addition, the ureteric orifices may lie closer to the incision than in a virgin bladder neck. It is important to identify the ureters (using methylene blue or indigo carmine if needed) and if necessary, intubate them with stents or feeding tubes until the bladder neck is mobilized and reconstructed. The incision should be distal to the ureters and continue through the bladder neck and any associated fibrosis.
2. The presence of a median lobe (Fig. 33.6): A median lobe may be deceptive and not always obvious when the anterior bladder neck is opened. The forceps via the third arm should be used to deflect the median lobe caudally in order to identify the posterior bladder neck and ureters. Occasionally, for larger median lobes, a figure-of-eight suture may be placed through the median lobe and the fourth arm can be used to retract and elevate the median lobe directly to facilitate exposure. The incision of the posterior bladder neck can then continue.

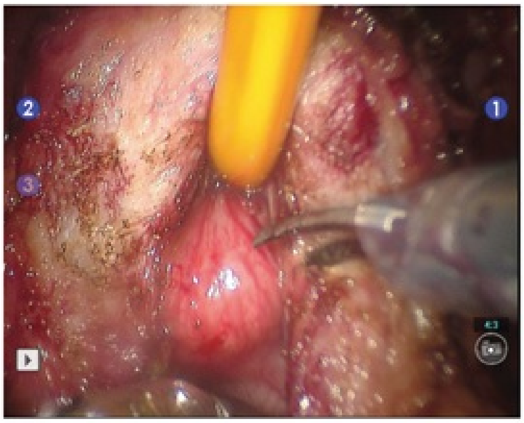

FIGURE 33.6 Identifying the presence of a median lobe with anterior retraction of the urethral catheter

The posterior bladder neck is incised with diathermy and sharp dissection (Fig. 33.7). Once divided, the curve of the scissors can be used to dissect behind the bladder neck exposing the anterior layer of Denonvilliers fascia which can be divided in the midline to expose the ampullae of the vasa and SV (anterior approach) or the previously dissected posterior plane. Prior to mobilizing the SV, access can be improved by widening the tissue lateral to the posterior bladder neck and clipping and dividing the lateral prostatic pedicles.

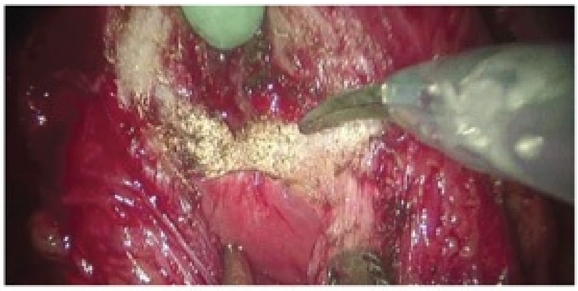

FIGURE 33.7 Incision of the posterior bladder neck

Dissection of the Vasa and Seminal Vesicles (Anterior Approach Only)

On each side, the fascia over the vas is incised. Each vas can be grasped and retracted out of the space anteriorly and mobilized before being clipped, along with its attendant vessels, and divided. This maneuver allows access to the posteromedial aspect of the SV. The SV should be fully mobilized along its medial aspect and posteriorly as far as its base. The dissection of the SV continues to its tip and the vessels in this area are clipped and divided, avoiding the issue of electrocautery near the neurovascular bundles (Fig. 33.8).

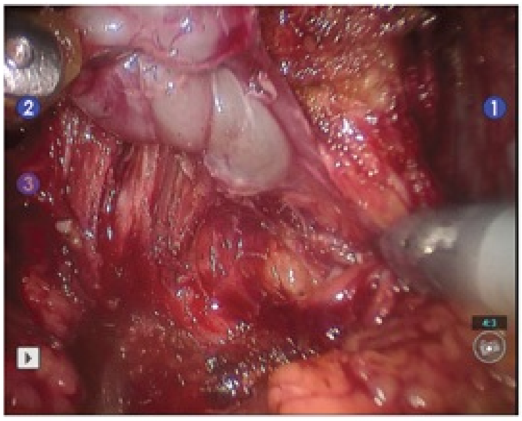

FIGURE 33.8 Dissection of the tip of the right seminal vesicle (being retracted anteriorly)

Posterior Dissection between Prostate and Rectum

Once free, the SV and vas on either side are retracted anteriorly to expose the posterior Denonvilliers fascia before entering the space behind the prostate and anterior to the rectum. The posterior layer of Denonvilliers fascia is incised horizontally just below the base of the SV to expose the perirectal fat. A combination of sharp and blunt dissection is used to mobilize the prostate from the rectum in the midline, extending out laterally toward the outer margins of the gland. It is critical to free the prostate from bladder neck to apex and to its lateral margins. Depending on the risk of extracapsular extension, the posterior layer of Denonvilliers fascia may be taken with the prostate or left on the rectum.

Vascular Control of the Lateral Pedicles and Nerve-Sparing Technique

The lateral pedicles are clipped with Hem-O-Lok clips close to the prostate and divided using electrocautery judiciously (Fig. 33.9). Following this step, it is important to avoid electrocautery whenever possible. The timing of nerve preservation is debatable. The dissection can take place either before the bladder neck is opened or as late as following posterior prostatic mobilization. The principle, however, is the same. The neurovascular bundle (NVB) is enclosed within the two thin layers of the periprostatic fascia. The fascia on the lateral prostate should be incised on the anterior lateral part of the gland, parallel to the NVB. The fascia is swept laterally away from the gland and the dissection is continued proximally to the junction between bladder and prostate and distally to the prostatic apex (Fig. 33.10). If the appropriate plane is entered, this is a mostly avascular dissection although several perforating micropedicles are often encountered entering the prostate. Bleeding here is typically self-limited but can be controlled with a 4-0 Monocryl suture if needed on the NVB precisely and superficially. Gentle sharp and blunt dissection are used to free the fascia and the NVB along its entire length from apex to bladder neck. Care must be taken to avoid traction injury to the NVB during this step.

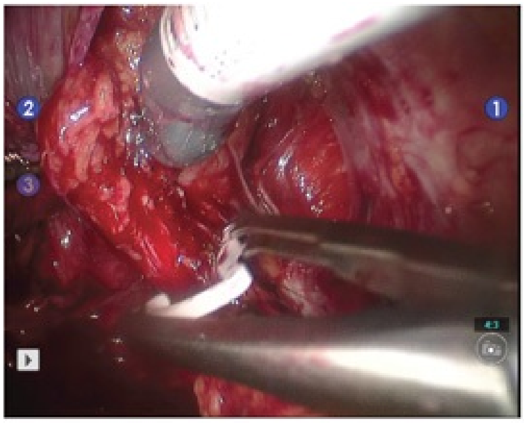

FIGURE 33.9 Control of the prostatic vascular pedicle with placement of Hem-o-lok (Weck) clip

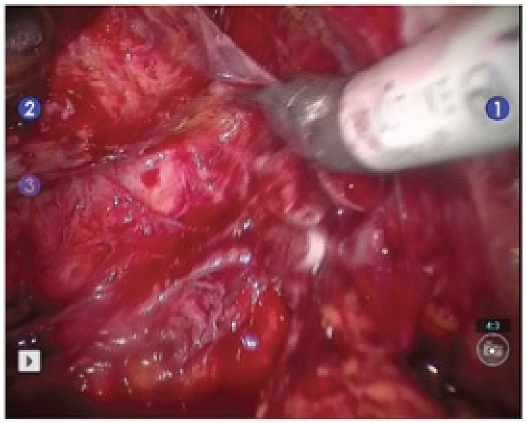

FIGURE 33.10 Nerve-sparing technique with athermal lateral displacement of the right neurovascular bundle

Division of the Dorsal Vein Complex and Urethra

If the 30-degree camera was used for the bladder neck dissection, it should be changed to a 0-degree camera at this time. The prostate by now is fully mobilized apart from the urethra/DVC complex. The fourth arm is used to provide gentle caudal traction on the “back-bleeder” suture on the prostate. The DVC is divided using electrocautery (Fig. 33.11) and the urethra is identified. The anterior urethra is then opened 1 to 2 mm distal to the apex using the cold scissors and the urethral catheter exposed (Fig. 33.12). Using the bipolar forceps, a plane posterior to the urethra and anterior to the rectourethralis muscle is identified and sharply divided. Remaining attachments to the posterior apex from the rectourethralis are divided and the specimen is delivered into a 10-mm laparoscopic specimen catch bag.

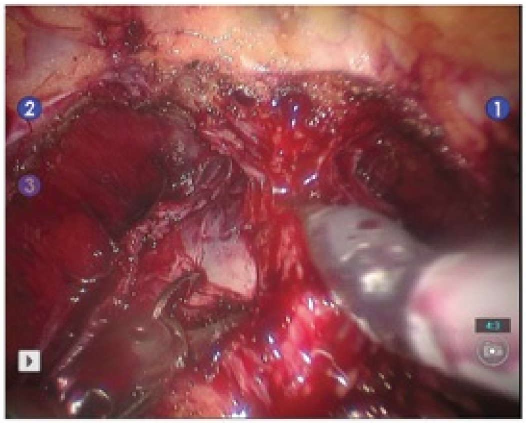

FIGURE 33.11 Division of the ligated dorsal vein complex using electrocautery

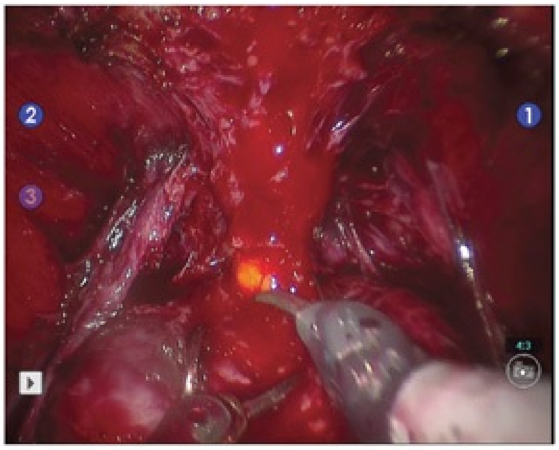

FIGURE 33.12 Incision of the anterior urethra with cold scissors

Vesicourethral Anastomosis

A posterior reconstruction of the musculofascial tissue is commonly performed using the “Rocco” technique, which has been demonstrated to markedly shorten the time to continence (16). Some surgeons advocate for additional techniques that may speed the return to continence such as anterior reconstruction or a periurethral suspension stitch, but we do not routinely perform these given the very high rates of continence with the Rocco technique alone. A 3-0 barbed monofilament suture is used to reapproximate the remnant of Denonvilliers fascia and the tissue of the posterior bladder wall cranial to the bladder neck. This maneuver reduces tension on the anastomotic suture by reducing the distance between the bladder and the urethra and promotes hemostasis by securing the bladder to the prostate bed.

There are a number of described approaches to the vesicourethral anastomosis. Typically, the anastomosis is performed with a double-ended barbed 3-0 monofilament suture commencing posteriorly at six o’clock. The suture continues between the bladder neck and the urethra in both clockwise and counterclockwise directions (Fig. 33.13) until the ends meet at 12 o’clock, where the suture is tied (Fig. 33.14). On completion, the integrity of the anastomosis is tested by passing a new 18Fr Foley catheter and filling the bladder with 240 mL of sterile water. If the anastomosis is water tight, no drain is required. If a drain is used, it can be placed through the fourth robotic port and secured following port removal.

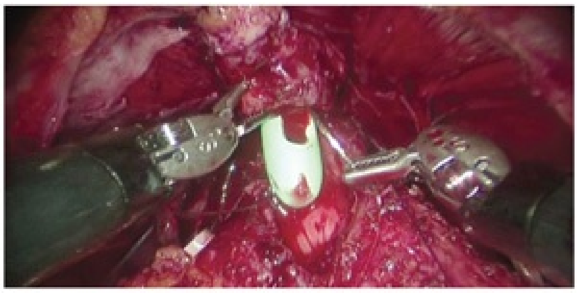

FIGURE 33.13 Placement of vesicourethral anastomotic sutures

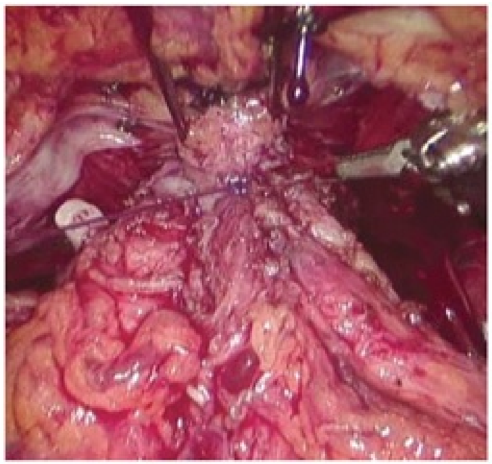

FIGURE 33.14 Completion of the vesicourethral anastomosis

Specimen Retrieval and Port Closure

The robot is undocked and the fascia of the lateral assistant port is closed using the Carter-Thomason technique with a 0-Vicryl suture under laparoscopic guidance. This port is then reintroduced and the camera is then located here so that the sutures to the Endocatch bags containing the prostate and pelvic lymph nodes can be brought through the midline camera port. This port is enlarged slightly to facilitate delivery of the pathologic specimens. The extraction site is closed with multiple 0-Vicryl sutures on a UR needle in a figure-of-eight fashion. Insufflation is then reestablished and the abdomen and pelvis is inspected one final time for hemostasis and to ensure that all fascial closures are intact. Incisions are closed with 4-0 Monocryl suture and Dermabond.

Postoperative Care

The patient usually requires minimal analgesia in the postoperative period. Our postoperative pathway consists of standing Tylenol and Toradol with breakthrough narcotic as needed. The majority of patients will not use narcotics in the postoperative period.

The patient can eat and drink immediately and should be ambulating in the early postoperative period. Most patients are discharged either on the day of surgery or day 1. The urethral catheter is left in situ for 5 to 7 days and removed. Routine cystogram is unnecessary.

Postoperative Complications

Bleeding is usually minimal with average blood loss of less than 200 mL. In the authors' cumulative experience of several thousand cases, transfusion rates are close to 0 and return to the operating room for bleeding occurs in less than 0.1% of cases. Significant infections are uncommon and other than perioperative antibiotics, no additional antibiotics are prescribed. Port site hernias are uncommon with meticulous closure technique and laparoscopic inspection of the extraction site closure prior to completion of surgery.

Bowel injury is potentially the most serious complication, albeit rare. Any tears, partial or full-thickness, in colon or small bowel can be repaired with a two-layer closure. If rectal injury is suspected, a soft 20Fr tube can be inserted into the rectum and then the injury can be identified by filling the pelvis with saline and blowing air into the rectum. If a rectal injury is found and there is minimal contamination, it should be repaired with a running two-layer closure and broad-spectrum antibiotic coverage should be commenced. A colostomy is only required if there is significant fecal contamination or signs of sepsis.

Initially, perioperative outcomes in regard to blood loss, transfusion requirement, length of stay, narcotic usage, and catheter duration following RALP were considerably shorter than were seen with open techniques. One major result of this technology has been that open surgeons have adopted RALP postoperative pathways for discharge and catheter duration, mitigating some of these differences (17,18). Long-term functional outcomes for urinary control and erections following RALP appear to be similar to those of open and laparoscopic surgery and are likely to vary more by surgeon and experience than by surgical approach (19,20).

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CHAPTER 34 BRACHYTHERAPY FOR LOCALIZED PROSTATE CANCER

EVA MARIE SUAREZ, HARRY S. CLARKE, AND DAVID T. MARSHALL

The term *brachytherapy* describes the process of placing a radioactive source directly inside or in close proximity to the intended target. The use of brachytherapy in prostate cancer was first reported by Pasteau and Degrais in 1913 (1), and various techniques have been explored since. Retropubic implantation of radioactive sources was used initially until the introduction of the transrectal ultrasound (TRUS) probe in the early 1980s (2). Significant advancements in ultrasound technology have led to ultrasound-guided transperineal prostate brachytherapy as the currently accepted technique used for prostate brachytherapy and has experienced substantial growth over the last 20 years.

Brachytherapy offers several advantages over radical prostatectomy, including patient convenience, no surgical incision, decreased anesthesia requirement, minimal blood loss, rapid recovery, and less risk of incontinence. Brachytherapy also offers advantages over external beam radiation therapy (EBRT). Proper brachytherapy technique can lead to decreased radiation dose to surrounding structures, thereby limiting normal tissue toxicity. Evidence continues to accumulate demonstrating the importance of dose escalation in prostate cancer. In order to deliver an acceptable dose via EBRT, patients may undergo several weeks of treatment, whereas brachytherapy can be completed during an outpatient procedure or a short hospitalization. Finally, the position of the prostate and surrounding critical organs may be difficult to reproduce daily during a protracted course of treatment, which may lead to an increased dose to normal tissues or a decreased dose to the prostate. Potential disadvantages to brachytherapy compared to external beam radiotherapy are that it may take longer to develop brachytherapy skills, is at least minimally invasive with a higher risk of urinary retention, and requires anesthesia. Compared to surgery, the risk of bowel changes and toxicity may be greater with brachytherapy.

Three isotopes (^{125}I, ^{103}Pd, and ^{131}Cs) are now available for low-dose-rate (LDR) brachytherapy. The majority of the radiation dose is delivered over 2 to 10 months, depending on which isotope is used. The timing and severity of acute side effects have been described regarding the different sources; however, no convincing evidence is available to recommend one source over another. LDR brachytherapy involves the transperineal placement of radioactive seeds into and around the prostate. The seeds remain in place permanently but lose radioactivity over time. High-dose-rate (HDR) brachytherapy has been increasingly utilized as well. Catheters are placed within the prostate as described in the following text for LDR needles, and a dosimetric plan is developed with computerized tomography (CT) or TRUS imaging and computer planning. An iridium-192 source can then be moved in and out of each catheter remotely via a computer-controlled robotic device. The time the radioactive source spends in each catheter and at each dwell position within each catheter can be manipulated via computer control to achieve a conformal radiotherapy plan. HDR brachytherapy typically requires a short hospital stay and 2 to 10 treatments over a 1- to 5-day period.

DIAGNOSIS

The diagnosis and risk stratification of prostate cancer is via 12 to 16 core prostate biopsies following an elevated prostate-specific antigen (PSA) or abnormal digital rectal exam. Patients with high risk of seminal vesicle involvement, such as those with large nodules on exam or perineural invasion seen on prostate biopsy, should undergo TRUS-guided biopsy of the seminal vesicles. Magnetic resonance imaging (MRI) can also be used to detect otherwise occult seminal vesicle involvement or extracapsular extension. Pelvic lymphadenectomy is not commonly performed for patients with low-risk disease. Patients with high risk of lymph node involvement (patients with seminal vesicle involvement, Gleason score >7, PSA >20) may benefit from laparoscopic pelvic lymph node dissection as nodal involvement changes treatment recommendations.

INDICATIONS FOR SURGERY

When considering brachytherapy as monotherapy for prostate cancer, it is critical to carefully select patients with low-risk disease or those with favorable intermediate risk disease. A number of tools have been developed to aid the physician when making this selection, including the Partin tables (3) and the Roach formulas (4,5). These tools can help estimate the risk of extraprostatic extension, seminal vesicle invasion, and pelvic lymph node involvement. Recommendations have been made regarding classification of patients into low-, intermediate-, and high-risk categories as illustrated in Table 34.1. Low-risk prostate cancer can be summarized as PSA <10, Gleason score <7, and clinical stage <T2b. Other risk factors, such as presence of perineural invasion or lymphovascular space invasion, and number of cores positive on biopsy, should be considered when stratifying patients and choosing appropriate treatment modalities. Recent literature also demonstrates acceptable outcomes when treating patients with favorable intermediate risk disease with brachytherapy as monotherapy. Typically, patients who have only one intermediate risk factor are considered (6,7), but data is emerging demonstrating excellent control rates for higher risk patients with or without a short course of androgen deprivation therapy (ADT) (6,8,9).

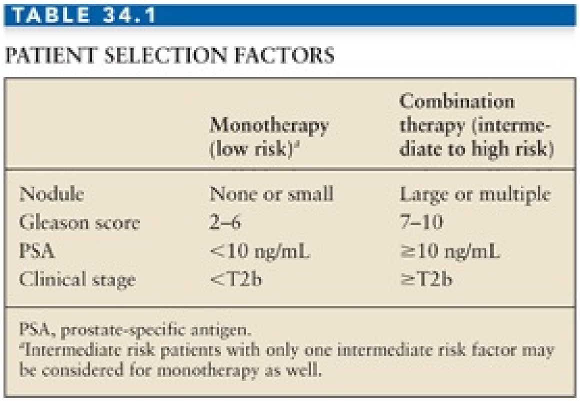

TABLE 34.1

PATIENT SELECTION FACTORS

	Monotherapy (low risk)[a]	Combination therapy (intermediate to high risk)
Nodule	None or small	Large or multiple
Gleason score	2–6	7–10
PSA	<10 ng/mL	≥10 ng/mL
Clinical stage	<T2b	≥T2b

PSA, prostate-specific antigen.

[a] Intermediate risk patients with only one intermediate risk factor may be considered for monotherapy as well.

Brachytherapy alone is not generally recommended as monotherapy for higher intermediate or high-risk patients. However, there is a growing body of evidence supporting the use of brachytherapy as a boost when combined with EBRT and ADT for higher risk disease (10–14). Brachytherapy is used in this situation as a very effective method of dose escalation. One recently reported trial from Canada, called the Androgen Suppression Combined with Elective Nodal and Dose Escalated Radiation Therapy (ASCENDE-RT) trial, randomized patients to dose-escalated EBRT with short-course ADT versus EBRT plus LDR brachytherapy with short-course ADT (15). In preliminary reports, LDR brachytherapy was shown to improve PSA control. Nine-year Kaplan-Meier relapse-free survival estimates were 63% for dose-escalated EBRT versus 83% for EBRT plus LDR brachytherapy.

ALTERNATIVE THERAPY

Prostate brachytherapy can be an ideal treatment for men with localized, low-risk prostate cancer, but good alternatives exist and may be more appropriate in certain situations. Men with high International Prostate Symptom Scores (IPSS), large prostate volume, or history of previous transurethral resection of the prostate (TURP) may tolerate EBRT or prostatectomy better than brachytherapy while achieving a similar therapeutic outcome. High IPSS before treatment predicts significant risk of severe lower urinary tract symptoms (LUTS) and acute urinary obstruction following brachytherapy (16). Similarly, large prostates have been shown to be at increased risk for urinary retention (17), although the absolute risk may still be low depending on the technique used (18). Patients with a history of prior TURP may be at increased risk for significant toxicity, including incontinence, if LDR brachytherapy is used (19,20), especially if the residual TURP deficit is large. This risk may be less with HDR brachytherapy (20a).

LOW-DOSE-RATE BRACHYTHERAPY

Selection of Isotope

Three isotopes (^{125}I, ^{103}Pd, and ^{131}Cs), as noted earlier, are currently being used for LDR prostate brachytherapy. Each delivers radiation to a volume of tissue within millimeters of each source. They differ in initial activity, dose rate, and half-life, as illustrated in Table 34.2. Some investigators believe ^{103}Pd may be more effective than ^{125}I at eradicating more rapidly proliferating tumors due to higher initial activity (20 to 25 cGy per hour and 7 to 10 cGy per hour, respectively). This belief has been propagated by convincing mathematical models and has led to the emergence of ^{131}Cs (32 cGy per hour) as another option. However, no conclusive clinical evidence proving this theory has yet been published, and one clinical trial has shown equivalence between ^{125}I and ^{103}Pd regarding PSA control at 3 years (21). The current recommended doses for the three isotopes in monotherapy and in combination with external beam therapy are shown in Table 34.3.

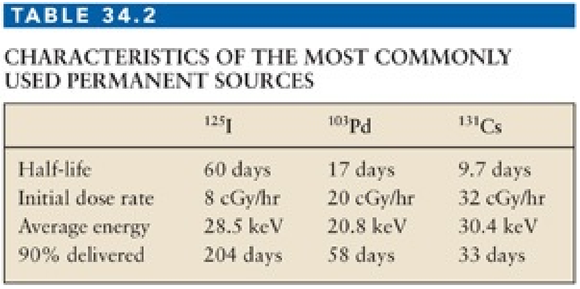

TABLE 34.2

CHARACTERISTICS OF THE MOST COMMONLY USED PERMANENT SOURCES

	^{125}I	^{103}Pd	^{131}Cs
Half-life	60 days	17 days	9.7 days
Initial dose rate	8 cGy/hr	20 cGy/hr	32 cGy/hr
Average energy	28.5 keV	20.8 keV	30.4 keV
90% delivered	204 days	58 days	33 days

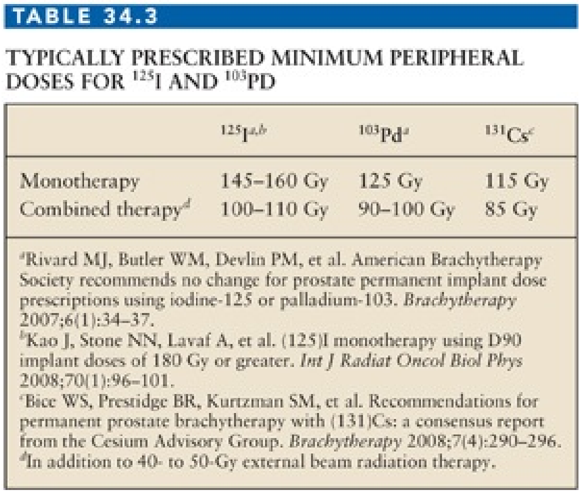

TABLE 34.3

TYPICALLY PRESCRIBED MINIMUM PERIPHERAL DOSES FOR ^{125}I AND ^{103}PD

	$^{125}\mathrm{I}^{a,b}$	$^{103}\mathrm{Pd}^{a}$	$^{131}\mathrm{Cs}^{c}$
Monotherapy	145–160 Gy	125 Gy	115 Gy
Combined therapy[d]	100–110 Gy	90–100 Gy	85 Gy

[a] Rivard MJ, Butler WM, Devlin PM, et al. American Brachytherapy Society recommends no change for prostate permanent implant dose prescriptions using iodine-125 or palladium-103. *Brachytherapy* 2007;6(1):34–37.

[b] Kao J, Stone NN, Lavaf A, et al. (125)I monotherapy using D90 implant doses of 180 Gy or greater. *Int J Radiat Oncol Biol Phys* 2008;70(1):96–101.

[c] Bice WS, Prestidge BR, Kurtzman SM, et al. Recommendations for permanent prostate brachytherapy with (131)Cs: a consensus report from the Cesium Advisory Group. *Brachytherapy* 2008;7(4):290–296.

[d] In addition to 40- to 50-Gy external beam radiation therapy.

Treatment Planning

Prostate LDR brachytherapy has evolved significantly over the years, and two methods now predominate: preplanned implant as popularized by the Seattle Prostate Institute and intraoperative planning as developed at Mount Sinai School of Medicine (MSSM) in New York.

Preplanning Approach

With this approach pioneered in Seattle (22), the patient is placed in the dorsal lithotomy position (Fig. 34.1) and an imaging study of the prostate is performed using TRUS (Fig. 34.2) 1 to 2 weeks before the implant. This image data set is imported into the brachytherapy planning software and utilized to develop an optimized plan. The number of seeds ordered for the procedure is then determined from this preplan. The patient is taken to the operating room (OR) on the day of the procedure and is positioned as he was on the day of planning. It is critically important that the patient's preplanning position is reproduced as accurately as possible in the OR. Seeds are then placed within the prostate with TRUS guidance (Fig. 34.3) using needles preloaded with seeds or strands of connected seeds according to the previously developed plan. Alternatively, seeds may be placed with a gun-type applicator, such as the Mick applicator (Mick Radio-Nuclear Instruments, Mount Vernon, New York), based on the planning study completed earlier. With the preplanned approach, the Mick applicator allows the practitioner to make minor adjustments to more accurately reproduce the preplanning study. A combination of preloaded needles and free seeds placed with the Mick applicator can also be used.

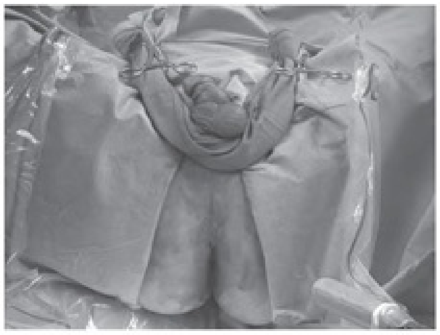

FIGURE 34.1 Patient prepared for TRUS in the dorsal lithotomy position.

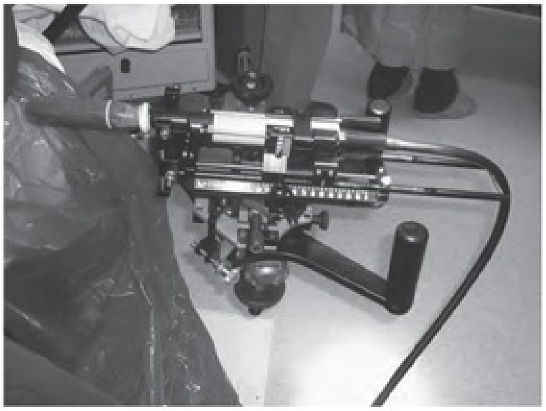

FIGURE 34.2 TRUS probe in ratcheting cradle/stepper.

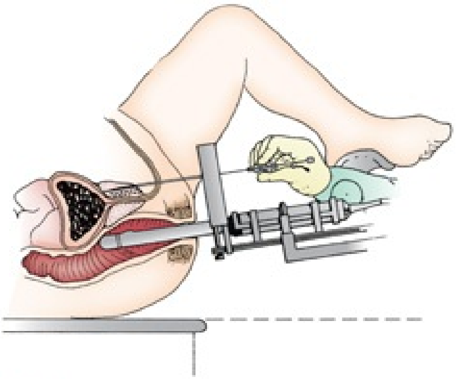

FIGURE 34.3 Schematic of the closed, ultrasound-guided implantation technique.

Real-time Intraoperative Planning Approach

With this approach developed by Stock et al. at MSSM (23), no preplanning study is acquired; however, the prostate volume is measured via a CT, MRI, or TRUS study at some point prior to the day of the implant in order to determine how many seeds to order for the procedure. This can be the volume determined at TRUS done for the initial biopsy. The patient is then brought to the OR and placed in the dorsal lithotomy position. TRUS is used to localize the bladder, urethra, prostate, seminal vesicles, and anterior rectal wall in three-dimensional space, and these data are recorded in the intraoperative treatment planning software (Fig. 34.4). An initial intraoperative plan is then developed based on a prostate volume-to-activity nomogram developed at MSSM. Needles are placed in the periphery of the prostate at approximately 1-cm intervals (Fig. 34.5). Once the needles are placed, images are reacquired to account for changes in size, shape, and position of the prostate that occurs with the inflammation induced by multiple needle placement (Fig. 34.6). The plan is optimized for actual position of the needles and for any changes in shape of the prostate due to needle placement. Longitudinal views on the TRUS are used to observe placement of the seeds into the prostate according to the intraoperative plan (Fig. 34.7). Seeds are most often placed using a Mick applicator. Typically 75% of the required activity is placed in the periphery of the gland, while 25% is placed in the interior of the gland. Then needles are placed in the central portion of the gland and the Mick applicator is then used to place the remaining 25% of the required activity in the gland according to the intraoperative plan. The majority of the inner seeds are placed at the apex and base of the gland in order to "cap" the prostate. Using modern treatment planning software and TRUS, the actual seed location can be documented as the seeds are placed and the intraoperative plan can better reflect reality, allowing for dosimetric inadequacies to be detected and corrected during the procedure.

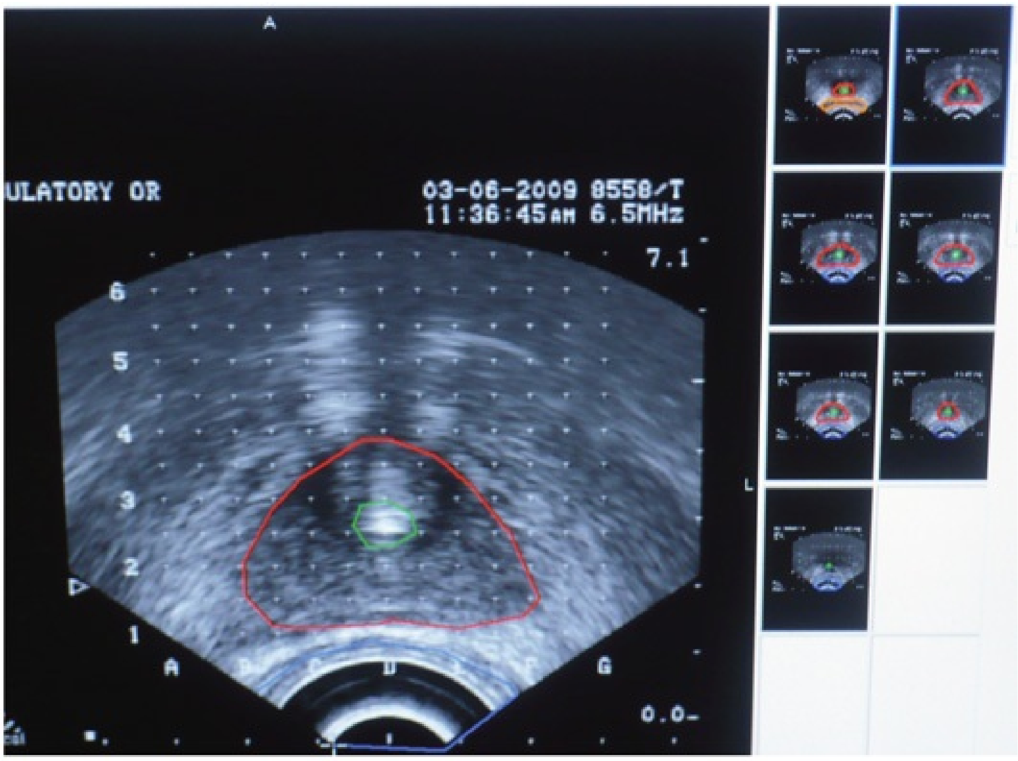

FIGURE 34.4 Ultrasound imaging of the prostate, urethra, seminal vesicles, and rectum in the intraoperative treatment planning system before needle placement. This data set is used to create the "preplan" in the OR.

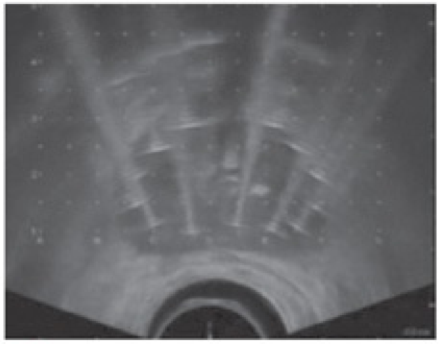

FIGURE 34.5 Axial ultrasound image of the prostate after peripheral needles have been placed.

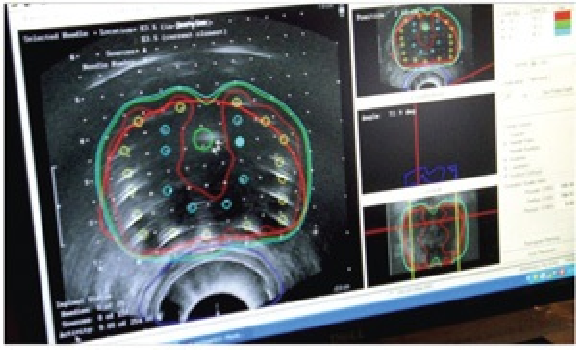

FIGURE 34.6 Treatment planning transverse and axial images of the prostate showing preliminary isodose lines for a ^{103}Pd implant (prescription dose = 100 Gy).

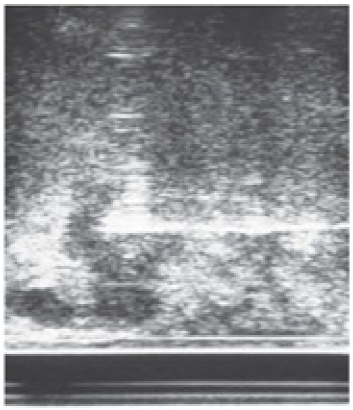

FIGURE 34.7 Longitudinal ultrasound view of seeds being deposited in the prostate.

This approach offers many advantages over the previously described technique as well as some disadvantages. The most significant advantage is that intraoperative planning allows for real-time optimization of the plan as each seed placed in the prostate is accounted for in the planning software and the resultant isodose lines are generated. No preplan is needed. Three variables unaccounted for with the preplanned technique, including changes in prostate size and shape with needle placement, needle deviation from planned position, and seed movement from initial placement, can be actively detected in the intraoperative treatment planning software and therefore corrected with subsequent seed deposition. Disadvantages include potentially longer procedure duration and Mick applicator utilization, which some practitioners may find unwieldy. Although the Mick applicator requires significant operator skill, in practiced hands, this applicator allows precise placement of individual seeds and significant flexibility. Some investigators have noted seed migration when seeds are placed individually in the prostate and surrounding tissues and have therefore argued for the use of stranded seeds. In fact, seeds have been observed to move significant distances and even to the lungs or other remote locations. When compared to stranded or linked seeds, single seed placement has been documented to result in increased overall seed migration (24,25). However, this has not been definitively shown to affect overall dosimetric outcome or toxicity (26–28).

Hybrid Approach with Real-time Planning and Linked Seeds

A novel technique has been developed and is currently being pursued at several institutions in an attempt to combine the advantages of real-time intraoperative planning and linked seeds (29–32). This technique is very similar to the intraoperative planning technique described earlier; however, strands or links of seeds are formed in the OR at the time of implant in response to real-time treatment planning. As before, an imaging study is obtained before the date of implant to determine the prostate volume, and an appropriate number and activity of seeds are ordered according to a nomogram. On the day of implant, the patient is placed in the dorsal lithotomy position and TRUS is utilized to build a three-dimensional model of the prostate, bladder, and anterior rectal wall within the treatment planning system as described earlier in the intraoperative planning approach. An initial intraoperative plan is then developed by the radiation oncologist while the urologist places needles in the periphery of the prostate at approximately 1-cm intervals under TRUS guidance (as in Fig. 34.5). Once the needles are placed, images are reacquired and the plan reoptimized. Longitudinal views of each individual needle are used to calculate the distance each needle traverses through the prostate. A device such as the QuickLink push-button delivery system (C. R. Bard, Inc, Covington, Georgia) or other method of linking seeds is then used to construct links of the appropriate number of seeds for the length measured along the longitudinal path of each needle in the prostate (Fig. 34.8). Each strand can be customized according to the number of seeds needed, and the overall length of the needle path in the prostate via custom-sized linkers or spacers. The linked seeds are then transferred to the prostate via the appropriate needle in a manner similar to that used with a preloaded needle in a preplanned approach (Fig. 34.9). The process is then repeated until all peripheral seeds have been placed. The inner needles are then placed (usually five to seven). The plan is then reoptimized to determine placement of the remaining required activity. Once the plan has been approved, the remaining interior links of seeds are constructed and placed within the prostate as described earlier. Multiple studies have demonstrated this hybrid planning approach provides similar quality of dosimetry and OR times, once the learning curve has been met, as compared to the traditional gun method (30,31,33).

FIGURE 34.8 Custom-constructed linked seeds. Note asymmetrical seed pattern that can be constructed in the OR according to the real-time plan.

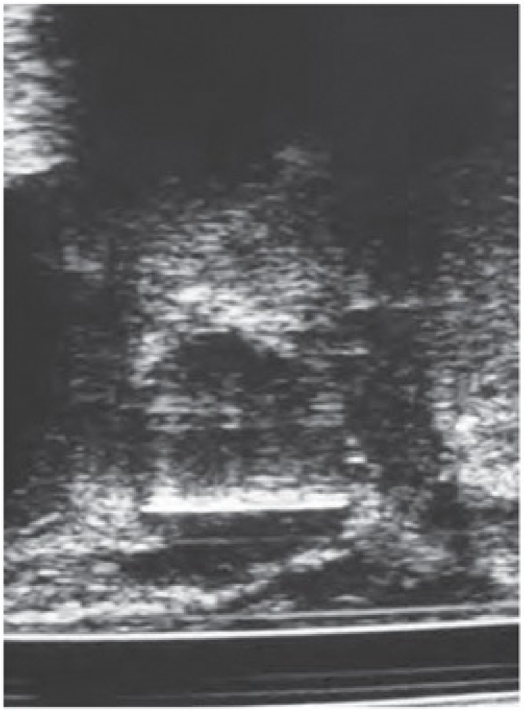

FIGURE 34.9 Longitudinal ultrasound image of linked seeds in prostate after implantation.

Postimplant Visualization

Following prostate seed implantation, flexible cystoscopy may be performed to verify an intact urethra and bladder wall and to account for any misplaced seeds in the bladder or protruding through the urethral wall. C-arm radiography may also be performed to verify seed position and to document the presence or absence of loose seeds in the bladder.

Postimplant Dosimetry

Postimplant dosimetry should be obtained at a consistent interval following prostate seed implant; however, the most appropriate interval is yet to be determined. Many institutions have patients return at 1 month following the implant for CT imaging. This image data set can then be imported into the treatment planning system, allowing for determination of dosimetric end points. Using this study, seed count should be verified, and isodose curves at 50%, 80%, 90%, 100%, 150%, and 200% of the prescribed dose should be displayed on axial images of the prostate, urethra, bladder, and rectal wall. The prostate D90, or minimum dose delivered to 90% of the prostate, as well as normal tissue doses, such as rectal V100 (volume of rectum receiving 100% of the prescribed dose) and urethral D30 (dose to hottest 30% of the urethra), should be recorded (34).

HIGH-DOSE-RATE BRACHYTHERAPY

HDR brachytherapy was initially developed in the mid-1990s to provide an alternative to LDR brachytherapy as a boost to EBRT. It has gained popularity since its introduction given the multiple potential advantages HDR may offer. It eliminates radiation exposure to medical personnel and the need for patients to follow radiation precautions because they are not radioactive after their treatment. HDR brachytherapy also provides a greater number of dwell positions than the number of seeds typically used for an LDR case. More dwell positions in conjunction with adjustable dwell times allow for conformal planning, including potentially better urethral avoidance, and the ability to plan a concomitant boost if needed. Biologically, HDR also theoretically provides the advantage of delivering a high dose per fraction, which results in a greater biologic effective dose for a malignancy with a considerably low α/β ratio. It has been hypothesized that prostate cancer is such a malignancy, but long-term results from studies testing this theory have been mixed (35,36). Disadvantages of HDR compared to LDR include the requirement for catheters to stay implanted in the patient's perineum for the course of the therapy, and the need for multiple surgical procedures to place the catheters if the treatments are separated in time by more than a few days.

Isotope

Contrary to LDR brachytherapy, HDR brachytherapy uses one radioactive source to treat several patients. As previously mentioned, the most commonly used isotope is iridium-192. It has significantly higher energy emission in comparison to the sources used for LDR brachytherapy with an average photon energy of 0.38 MeV and a half-life of 73.8 days. This allows for a greater dose to be delivered to the tissues surrounding the source over a shorter period of time. Treatments administered with ^{192}Ir are therefore administered over several minutes as a single source is propelled by a computer-controlled stepper motor unit through the catheters that are placed in the OR. Given its relatively short half-life, care must also be taken to appropriately account for the decay of the isotope prior to the delivery of each fraction.

Surgical Technique

Similar to LDR brachytherapy, HDR brachytherapy also involves the placement of catheters in and around the prostate gland in the OR with the patient in the dorsal lithotomy position. After the patient is properly positioned, TRUS is used along with a template to aid in the placement of at least 14 catheters similar to placement described earlier for LDR brachytherapy. Typically, the patient will be transferred after catheter placement, and the template will have a locking mechanism to reduce displacement of the catheters during transfers. Fiducials can also be placed intraoperatively at the base and apex of the prostate gland not only for treatment planning but to also assess for changes in anatomy if multiple fractions are planned. No preplanning is required for HDR as this process takes place after catheter placement. No sources need be ordered for a particular patient as the HDR unit houses the source on site for use with multiple patients.

Treatment Planning

HDR brachytherapy planning uses a three-dimensional image data set to define a target treatment volume and avoidance structures similar to the intraoperative LDR approach described earlier. These images can be obtained intraoperatively by TRUS similar to LDR treatment planning or the patient can be transferred to a CT scanner after catheter placement and a CT data set used for treatment planning. The advantage of planning a treatment via ultrasound is this allows for the treatment to be administered without transferring the patient. However, in this case, the OR must be properly equipped with appropriate radiation shielding and have access to the HDR unit. Alternatively, the advantage of planning based on a postoperative CT scan is reduction in the post-acoustic shadowing caused by the catheters on ultrasound and improved visualization of the organs at risk with CT. Once the images are transferred to the treatment planning software, the physician contours the region to be treated, known as the clinical treatment planning volume (CTV), and the structures that are to be avoided, known as the organs at risk (OAR) including bladder, rectum, and urethra. The CTV should encompass the entire prostate and any extraprostatic extension of disease. In most practices, the CTV is equivalent to the planning treatment volume (PTV), although an additional margin for motion may be added to the CTV to form the PTV. The catheters are also identified on the image data set and registered to identify the available dwell positions along each catheter.

Computerized treatment planning algorithms use geometric or inverse planning to optimize the dose to the PTV while minimizing dose to the OARs. Differences in the dose distribution are created by varying the dwell positions used and the time the iridium source will stop at each position. The algorithm produces isodose volumes that represent the dose that will be delivered on the three-dimensional image set. The physician then has the opportunity to adjust the dose distributions either through manual optimization or by repeating the algorithm with different parameters. Generally adequate coverage of the PTV constitutes 90% to 95% of the PTV receiving at least 100% of the prescription dose. The maximum dose to the urethra, bladder, and rectum should also be calculated and recorded. Additional normal tissue parameters that should also be documented include the V100 of the urethra and the V75, D2cc, and D5cc of the rectum. Specific recommendations of the dose tolerance of each of these structures are dependent on the prescription dose and fractionation used, which vary widely (Table 34.4).

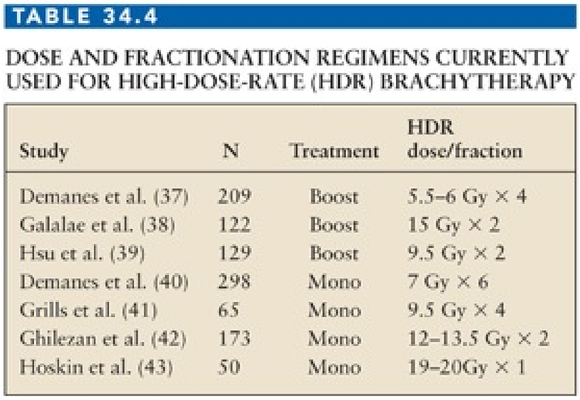

TABLE 34.4

DOSE AND FRACTIONATION REGIMENS CURRENTLY USED FOR HIGH-DOSE-RATE (HDR) BRACHYTHERAPY

Study	N	Treatment	HDR dose/fraction
Demanes et al. (37)	209	Boost	5.5–6 Gy × 4
Galalae et al. (38)	122	Boost	15 Gy × 2
Hsu et al. (39)	129	Boost	9.5 Gy × 2
Demanes et al. (40)	298	Mono	7 Gy × 6
Grills et al. (41)	65	Mono	9.5 Gy × 4
Ghilezan et al. (42)	173	Mono	12–13.5 Gy × 2
Hoskin et al. (43)	50	Mono	19–20Gy × 1

If multiple fractions are planned for the same implant, repeat imaging should be obtained to confirm the catheters have not migrated from their initial placement. The length of the catheters can also be measured as a guide for displacement in addition to changes in the location of the fiducial markers that were placed intraoperatively. Patient comfort must also be addressed between fractions with either an epidural or intravenous pain medication. If the patient will return to the OR for an additional insertion, care should be taken to provide a uniform dose distribution. This can be accomplished by replicating the patient's position from his previous implant and using a similar catheter distribution. Repeat imaging should also be performed for each insertion so the physician may contour the CTV and OARs on the new image data set. The previous plan can be superimposed on this data set and adjusted as needed or a new plan can be created.

Initially, prostate HDR brachytherapy was developed as a boost to EBRT but several institutions have implemented the technique as monotherapy. Dose and fractionation schemes are highly variable between institutions as demonstrated in Table 34.4 with a trend toward extreme hypofractionation, one to two fractions, to eliminate the need for multiple implants or epidural pain management. Generally two to four fractions are used when administered as a boost to EBRT with a range of 4 to 15 Gy per fraction. When used as monotherapy, a larger variability is noted, where one to seven fractions are administered at 6 to 20 Gy per fraction.

Posttreatment Care

At the completion of the HDR treatment, the catheters are removed and perineal pressure applied. Bladder irrigation is also commonly used to flush out any blood clots before the urinary catheter is removed. Antibiotics are commonly prescribed if the patient's treatment required hospitalization and may be continued after discharge at the discretion of the treating physician.

OUTCOMES

Complications

Immediate symptoms following brachytherapy are related to needle placement and include edema, bleeding, pain, and infection. The risk of infection can be minimized with the use of intraoperative antibiotics and a short course of postoperative antibiotics. Intraprostatic edema and bleeding in LDR brachytherapy may lead to urinary retention in approximately 5% to 15% of patients (4) and 1% to 12% for HDR brachytherapy (5,44). Large prostate volume and an elevated pretreatment IPSS predict an increased risk of urinary retention, and some studies have shown that a short course of androgen deprivation may reduce this risk particularly for LDR implants (18).

Urinary irritation may develop within 1 to 2 months after ^{125}I implantation and within 1 to 2 weeks with ^{103}Pd, ^{131}Cs or ^{125}Ir. These symptoms can be monitored and prospectively recorded through utilization of IPSS evaluation at each subsequent follow-up. The majority of men undergoing prostate brachytherapy will experience urinary symptoms such as increased frequency, dysuria, nocturia, and weakened stream, which can be treated symptomatically with alpha blockers and antimuscarinics. Most men will return to their baseline function at 1 to 2 years. Proctitis may also occur in approximately 15% of men and manifest as mild hematochezia typically 1 to 2 years after treatment. These symptoms can often be managed conservatively by avoiding constipation with stool softeners and in severe cases with argon-plasma coagulation.

Late complications associated with prostate brachytherapy include erectile dysfunction, a low risk of incontinence, and the remote possibilities of severe rectal injury or secondary malignancies of the pelvis. Rectal injuries such as a rectal-urethral fistula occur in less than 1% of cases (16). The risk of developing incontinence after LDR brachytherapy is limited except for men who have undergone a previous TURP or require a TURP for obstruction after brachytherapy (20). Currently, there is no evidence to suggest that patients who undergo HDR brachytherapy are at a similar risk if they had a previous TURP. Erectile function will likely decrease in 20% to 30% of men 2 to 3 years after brachytherapy, although the majority of these patients have improvement in their erectile function with pharmacologic agents. Finally, EBRT has been associated with an absolute 1% increase in secondary malignancies of the rectum or bladder as compared to patients undergoing prostatectomy alone (45). Theoretically, prostate brachytherapy would carry a similar risk, and at least one retrospective review has suggested that brachytherapy may be associated with a small increased risk of developing a bladder cancer after prostate brachytherapy (46).

Results

Defining and subsequently reporting prostate cancer outcomes has been the subject of much debate. Unlike with prostatectomy, PSA levels decrease but often do not become undetectable following radiation therapy. Therefore, the American Society for Therapeutic Radiology and Oncology Consensus Panel issued a consensus statement in 1997 defining biochemical failure following radiation therapy for prostate cancer as three consecutive increases in PSA value. The date of failure was defined as the midpoint between the postirradiation nadir PSA and the first of the three consecutive rises (47). These recommendations were found to be unwieldy and were subsequently revised in 2006 based on a consensus meeting in Phoenix, Arizona, to the current definition of a PSA relapse after radiotherapy (EBRT or brachytherapy): a PSA rise of 2 ng per mL or more above the nadir PSA with no backdating (48). This is referred to as the Phoenix criterion for PSA relapse.

Prostate cancer outcomes have been actively studied following brachytherapy, and long-term outcomes have now been published confirming the utility of this procedure as a boost to EBRT for all risk groups or as monotherapy for the low to intermediate risk groups. Table 34.5 summarizes nine series reporting long-term outcomes following brachytherapy as the sole intervention for localized prostate cancer. Freedom from PSA failure at 10 years is approximately 90% and compares favorably with outcomes obtained from other therapeutic options such as EBRT and prostatectomy. Table 34.6 summarizes six series that combined brachytherapy and EBRT. Long-term outcomes reveal that freedom from PSA failure at a minimum of 5 years is greater than 75% for intermediate-risk patients and greater than 60% for high-risk patients.

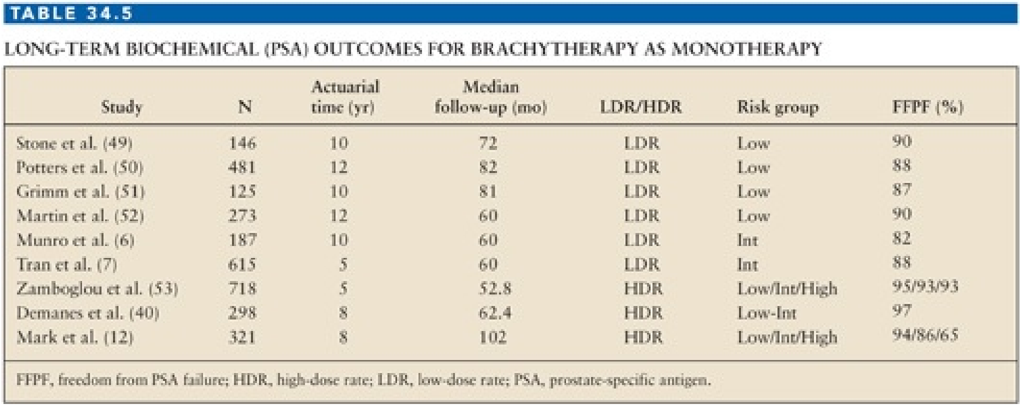

TABLE 34.5

LONG-TERM BIOCHEMICAL (PSA) OUTCOMES FOR BRACHYTHERAPY AS MONOTHERAPY

Study	N	Actuarial time (yr)	Median follow-up (mo)	LDR/HDR	Risk group	FFPF (%)
Stone et al. (49)	146	10	72	LDR	Low	90
Potters et al. (50)	481	12	82	LDR	Low	88
Grimm et al. (51)	125	10	81	LDR	Low	87
Martin et al. (52)	273	12	60	LDR	Low	90
Munro et al. (6)	187	10	60	LDR	Int	82
Tran et al. (7)	615	5	60	LDR	Int	88
Zamboglou et al. (53)	718	5	52.8	HDR	Low/Int/High	95/93/93
Demanes et al. (40)	298	8	62.4	HDR	Low-Int	97
Mark et al. (12)	321	8	102	HDR	Low/Int/High	94/86/65

FFPF, freedom from PSA failure; HDR, high-dose rate; LDR, low-dose rate; PSA, prostate-specific antigen.

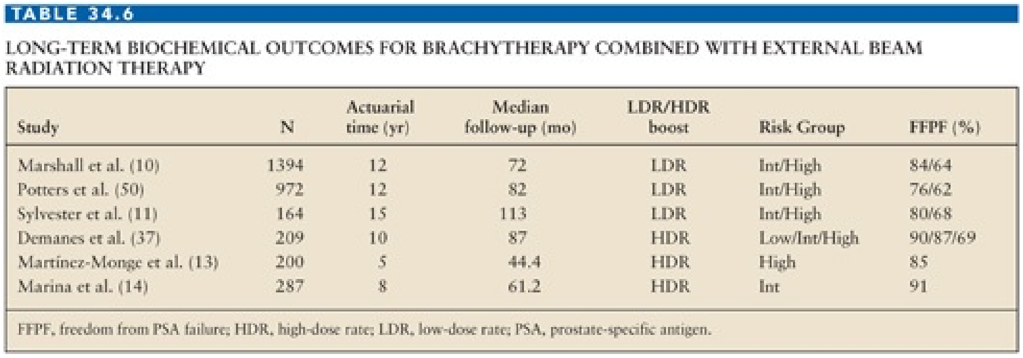

TABLE 34.6

LONG-TERM BIOCHEMICAL OUTCOMES FOR BRACHYTHERAPY COMBINED WITH EXTERNAL BEAM RADIATION THERAPY

Study	N	Actuarial time (yr)	Median follow-up (mo)	LDR/HDR boost	Risk Group	FFPF (%)
Marshall et al. (10)	1394	12	72	LDR	Int/High	84/64
Potters et al. (50)	972	12	82	LDR	Int/High	76/62
Sylvester et al. (11)	164	15	113	LDR	Int/High	80/68
Demanes et al. (37)	209	10	87	HDR	Low/Int/High	90/87/69
Martínez-Monge et al. (13)	200	5	44.4	HDR	High	85
Marina et al. (14)	287	8	61.2	HDR	Int	91

FFPF, freedom from PSA failure; HDR, high-dose rate; LDR, low-dose rate; PSA, prostate-specific antigen.

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CHAPTER 35 IMAGING, INNOVATION, AND NOVEL THERAPIES

ANDREW D. HARDIE, G. JOEL DECASTRO, AND SANDIP M. PRASAD

Historically, the use of imaging technologies to guide urologic therapies has been limited to ultrasound and fluoroscopy. With declining costs and increasing availability and quality of cross-sectional imaging, especially magnetic resonance imaging (MRI), the use and indications of these imaging technologies is ever-expanding. We will review the role of MRI in the diagnosis, evaluation, and management of prostate cancer.

MAGNETIC RESONANCE IMAGING OF PROSTATE CANCER

Unlike many other common oncologic diseases, the ability to evaluate prostate cancer by imaging had been limited until the development of modern MRI technology. Prostate MRI is increasingly performed clinically as a means of locally staging prostate cancer, and MRI has demonstrated a good performance which has steadily improved over time (1). However, the advent of newer advanced MRI technology and a new “multiparametric” approach to image interpretation has revolutionized the field. Although many of the technical requirements of MRI for imaging of prostate cancer are beyond the scope of this discussion, significant improvements in MRI field homogeneity, gradient strength, and to some degree the increased availability of high field strength 3 Tesla (3T) MRI have been critical to these improvements. These and many other technical advances have allowed for the development of multiple high-quality image sequences which evaluate different aspects of the prostate gland: (a) high-resolution T2-weighted (T2W), (b) diffusion-weighted (DW), and (c) dynamic contrast-enhanced (DCE) imaging. The combined interpretation of these three primary MRI sequences, termed *multiparametric imaging*, allows experienced radiologists to maintain a very high performance for identification of prostate cancers that are likely to be clinically significant.

Multiparametric Magnetic Resonance Imaging: T2-Weighted Magnetic Resonance Imaging

Spin-echo-based T2W MRI sequences form the basis of high-resolution prostate imaging. These images (in which water has high signal) allow excellent visualization of the margins and internal anatomy of the prostate gland as well as the seminal vesicles, lymph nodes, and bladder (2–4). The anatomic detail depicted on T2W sequences forms the foundation of the multiparametric approach to interpretation of prostate MRI (5,6). Examples of the typical prostate anatomy on the T2W sequence are depicted in Figure 35.1. However, T2W MRI has been shown to have poor specificity for prostate cancer when interpreted alone (7,8). Among the reasons for the poor performance is the similarity of the appearance of prostate cancer to commonly seen changes of prostatitis as well as that of benign prostatic hyperplasia (BPH) (6,7). Figures 35.2 and 35.3 depict typical findings at prostate MRI in clinical practice. Recently, there has been near universal adoption of an interpretation approach based on a combination of T2W and two other MRI sequences (DW and DCE) which is termed *multiparametric* (8). In fact, a standardized reporting language based on specific criteria from these three sequences has been proposed (9).

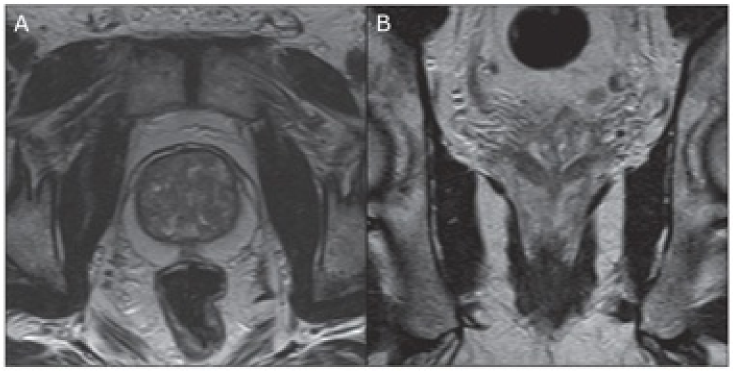

FIGURE 35.1 Axial T2W images demonstrating a normal appearance of the prostate (**A**) with diffuse high signal in the peripheral zone and mild BPH in the central gland. Coronal T2W image demonstrating a normal appearance of the seminal vesicles (**B**).

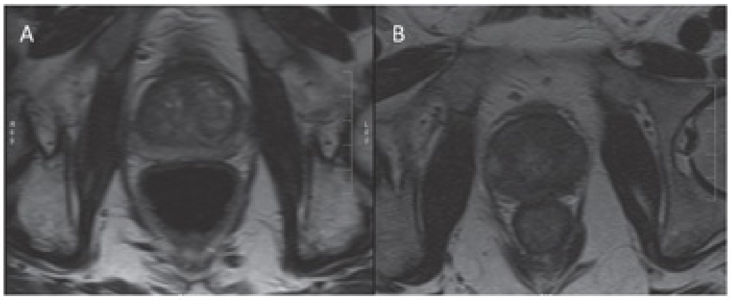

FIGURE 35.2 Axial T2W images demonstrating diffuse low level decreased signal in the bilateral peripheral zones (**A**) typical of benign prostatitis. Compare to a case with nearly diffuse dense low signal in the bilateral peripheral zone (**B**) typical of prostate cancer.

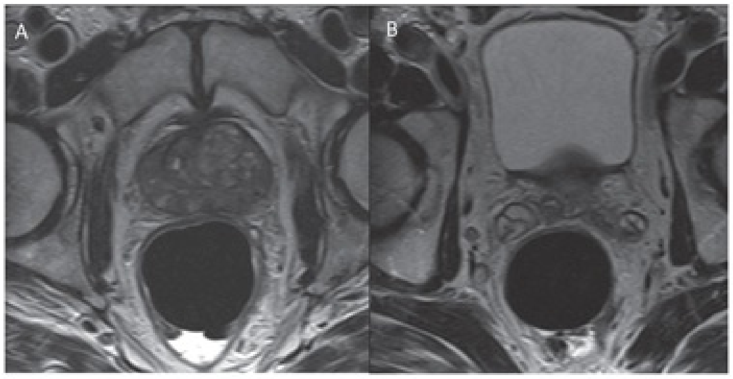

FIGURE 35.3 Axial T2W image demonstrating multiple dense areas of decreased signal in the bilateral peripheral zones (**A**) typical of multifocal prostate cancer. Axial T2W image demonstrating invasion of the seminal vesicles by tumor (**B**).

Multiparametric Magnetic Resonance Imaging: Diffusion-Weighted Magnetic Resonance Imaging

DW MRI is a technique that allows visualization of the random movement of water molecules (Brownian motion). This allows for a differentiation of tissues that have different levels of cellularity, based on the level of restriction of the natural random motion of water (10). Simple fluids, which have no restriction of this motion, are readily differentiated from the minimally cellular normal peripheral zone of the prostate and from highly cellular prostate cancer (11). An example case of prostate cancer with abnormal signal on DW-MR is depicted in Figure 35.4. Experience in the interpretation of DW-MR is necessary as the differentiation of prostatitis and BPH from cancer can still be problematic, as with the other sequences when read independently (8,9).

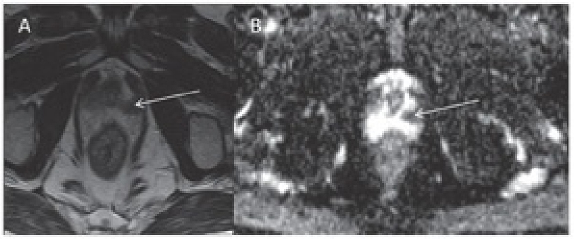

FIGURE 35.4 Axial T2W (A) and DW (B) sequences demonstrating a focus of tumor (*arrow*) in the left apical peripheral zone.

Multiparametric Magnetic Resonance Imaging: Dynamic Contrast-Enhanced Magnetic Resonance Imaging

The third essential sequence for high-quality prostate MRI, DCE MRI, assesses the vascularity of tissues in the prostate. In brief, intravenous gadolinium-based contrast agents are administered rapidly through automated bolus injectors and carefully timed MRI sequences are performed. Prostate cancer should be visible as tissue that has a rapid, early enhancement and rapid clearance (washout). Normal prostate tissue more often has a slower peak to the contrast enhancement curve and a more delayed clearance, although BPH can overlap in appearance (9,12). This method can be the most difficult technically and also takes experience in interpretation. Postprocessing technology exists in order to simplify the interpretation, although the addition of another layer of image processing can be yet another source of error; therefore, knowledge of processing artifacts is essential (12). DCE MRI images from the same patient as in Figure 35.4A are included in Figure 35.5.

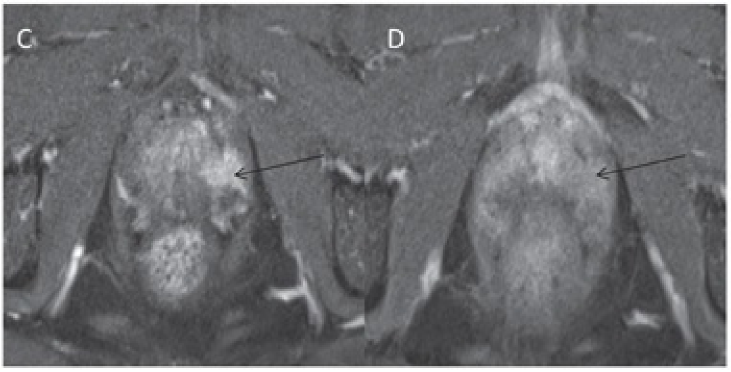

FIGURE 35.5 Axial early phase DCE (C) and late phase DCE (D) images demonstrating a focus of tumor (*arrow*) in the left apical peripheral zone with brisk enhancement and delayed contrast washout.

Performance of Magnetic Resonance Imaging for Prostate Cancer

Although the overall performance of multiparametric MRI for identifying prostate cancer is good, there can still be significant discrepancies between MRI interpretation and prostate biopsy results (8,9,13). A major point to consider is that until recently, most available research evaluating the correlation between MRI and prostate biopsy depended on the assumption that the areas identified on MRI could be well-correlated by transrectal biopsy or prostatectomy specimens. Many experienced researchers would likely acknowledge the major limitations of this approach. Recently, there is a growing body of research which uses more direct means of correlation including MRI-guided biopsy and real-time image fusion between MRI and transrectal ultrasound-guided biopsy (13–15). These methods have increased the ability to evaluate the performance of MRI, given the increased confidence of correlation between MRI and biopsy. However, MRI will not identify all or even nearly all prostate cancer. Clinically, the significance of such a reduced sensitivity for cancer has at least two potential outcomes. First, many of the cancers undetected by MRI are low-grade, clinically insignificant cancers (16). However, failure to identify cancers that would be deemed to be of low clinical significance by MRI may potentially represent a desirable outcome. However, clinically significant cancers can also be undetectable at MRI, leading to potentially deleterious patient outcomes. Therefore, despite the strong ability of MRI to identify cancer, the optimal clinical role of MRI in its diagnosis has not been established to date (17).

Prostate Magnetic Resonance Imaging in Clinical Practice

It is important to note that there is not a high clinical need for prostate MRI to identify all prostate cancer foci. In fact, the diagnosis of prostate cancer is often not difficult to obtain, given the high incidence of the disease and the high sensitivity of routine prostate biopsy for cancer. Although the exact role of prostate MRI has yet to be universally established, there has been a rapid expansion of the use of this technology based on published reports and anecdotal accounts. In the following sections, potential clinical roles for prostate MRI will be explored. Specifically, postulated clinical information which prostate MRI can supply in several common clinical scenarios will be reviewed.

Magnetic Resonance Imaging in Patients with a Biopsy Diagnosis of Low-Risk Prostate Cancer

The options for patients with a biopsy result consistent with low-risk prostate cancer include surgical or radiation treatment (often without concomitant hormonal therapy) as well as nontreatment approaches such as active surveillance. However, there is a potential risk of undertreatment or inappropriate inclusion into active surveillance monitoring due to undersampling of cancer with subsequent understaging. There is a growing body of literature demonstrating the ability of MRI to identify patients with higher risk cancers that were not initially sampled by biopsy (18,19). Figure 35.6 depicts an MRI of a patient with an initial biopsy of low-risk prostate cancer that was subsequently confirmed to have high-risk cancer following MRI and rebiopsy. Areas of the prostate gland prone to undersampling include the anterior and periurethral central gland (transitional zone) as well as portions of the peripheral zone located far laterally and apically. Therefore, an MRI performed following a low-risk cancer biopsy result may demonstrate areas worthy of rebiopsy. The fact that MRI demonstrates a relatively poor sensitivity for low-risk prostate cancer but a higher sensitivity for intermediate and high-risk cancers results in a potentially advantageous situation whereby many areas that undergo rebiopsy could upgrade the clinical risk of a patient’s prostate cancer. Conversely, if no areas of additional suspicion are identified on MRI, rebiopsy is unlikely to yield a higher risk cancer.

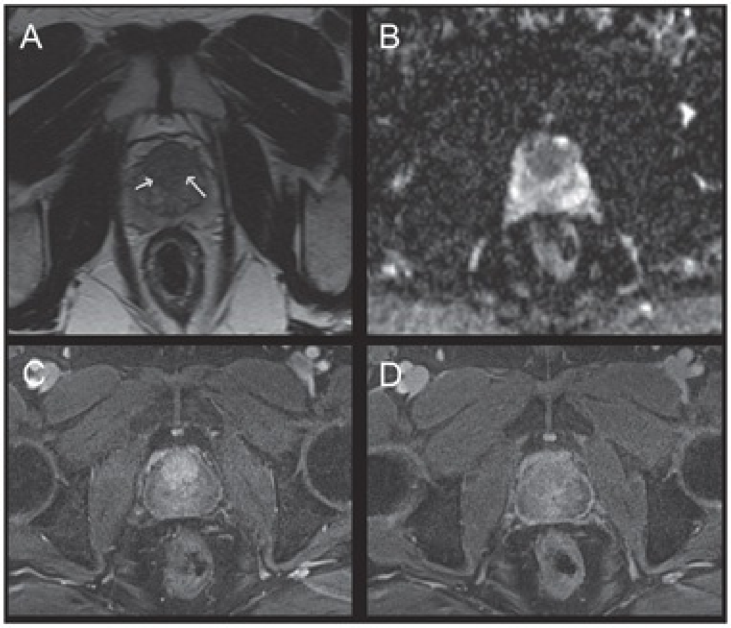

FIGURE 35.6 Axial T2W (A), DW (B), early phase DCE (C), and late phase DCE (D) image sequences demonstrating a large focus of tumor (*arrow*) in the far anterior central gland.

Magnetic Resonance Imaging in the Setting of Negative Biopsy

A significant portion of patients presenting for prostate biopsy will obtain a negative result. However, MRI can be employed in this scenario to evaluate selected patients with persistent clinical suspicion of cancer. As previously discussed, the value of MRI in this setting is that most clinically significant cancers will be visible on MRI, and biopsy can be directed at these areas. Conversely, a negative MRI result can serve as additional reassurance that the patient indeed is unlikely to harbor a clinically significant prostate cancer. Figure 35.7 depicts a patient with multiple sets of negative biopsies by standard 12-core method. A suspicious focus on MRI was found to represent Gleason 3+4 cancer.

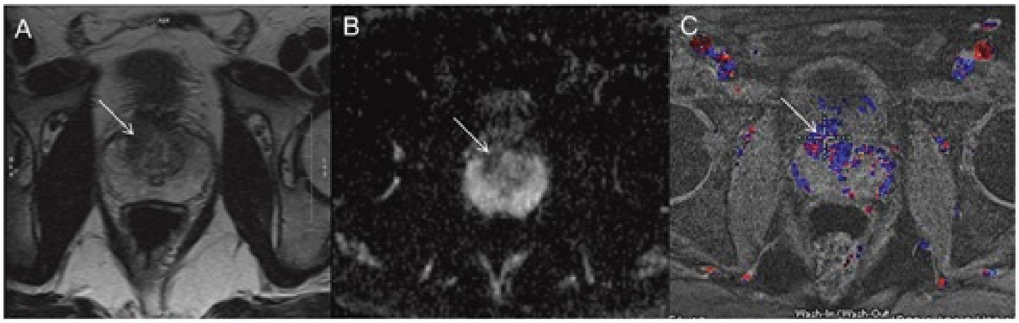

FIGURE 35.7 Axial T2W (A), DW (B), and post-processed color-coded DCE (C) image sequences demonstrating a focus of tumor (*arrow*) in the right central gland.

For many patients who undergo prostate MRI following negative 12-core biopsy, no suspicious foci will be identified on MRI. For these patients, the likelihood of a clinically significant cancer is likely low, although it has not been entirely eliminated. There is currently limited but ever expanding data available which attempts to address the question, “How long is a negative MRI good for?” Although this question cannot be answered with any degree of certainty yet, foci of prostate cancer may become detectable by MRI on follow-up MRI between 6 and 24 months (20,21). Figure 35.8 illustrates this finding.

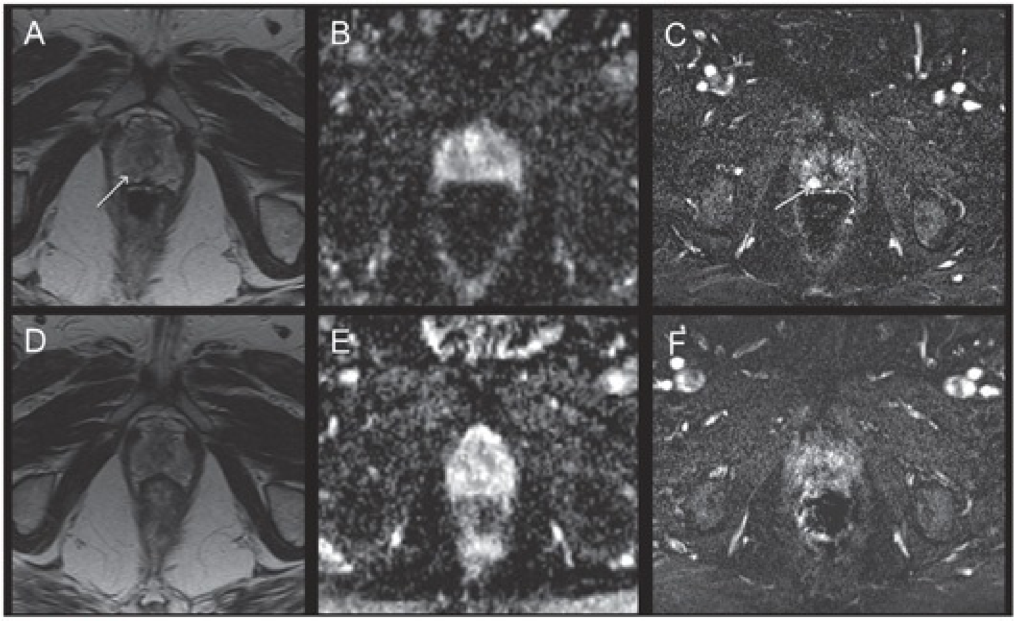

FIGURE 35.8 Axial T2W (A), DW (B), and early phase DCE (C) in a patient with a newly visible focus of tumor (*arrow*). Axial T2W (D), DW (E), early phase DCE (F) of the same patient from an MRI 2 years prior.

Use of Magnetic Resonance Imaging in Guidance for Biopsy of Suspected Prostate Cancer

As previously discussed, MRI has the ability to identify prostate cancer, particularly higher risk cancer, but suspicious MRI foci must be localized for biopsy. Although direct methods exist for biopsy of lesions on the MRI scanner, these approaches have been slow to penetrate clinical practice. Not only does direct MRI-guided biopsy require specialized equipment and subspecialty training not widely available, but the process can be time-consuming for MRI units which often have high diagnostic imaging utilization. Often, suspicious foci identified on MRI are referred back for transrectal ultrasound (TRUS) biopsy. One approach the TRUS operator can take is to attempt to visually identify the focus on ultrasound following review of the MRI. Given that many lesions identified on MRI can be identified on TRUS once the MRI images are reviewed, this approach can be successful and may improve overall accuracy of prostate grading (22). Recently, technology has become available, which can fuse the images from the MRI in real time with the TRUS during the biopsy procedure. This approach may ensure the most accurate correlation possible between lesions on MRI and biopsy results (22–24). Image guidance and image fusion technology will likely continue to improve.

Role of Magnetic Resonance Imaging Following Prior Therapies

Since the inclusion of gadolinium-based contrast-enhanced protocols, MRI has the ability to assess patients following prior therapeutic treatments for prostate cancer. The clinical scenario becoming most common for use of MRI is in the patient with evidence of biochemical failure following whole-gland prostate radiation (including both external beam and brachytherapy techniques). Although difficult, if not impossible, to discern on traditional T1- and T2-weighted sequences, recurrent/residual prostate tumor demonstrates enhancement following gadolinium contrast. Experience is necessary in interpretation of these images, given that some level of contrast enhancement of the gland can exist following radiation therapy and may be difficult to differentiate from diffuse tumor. However, asymmetric foci of enhancement in the gland can often be identified in addition to enhancing tumor outside the gland including in the seminal vesicles (25). Once identified, these foci can be readily localized for biopsy and potentially be used to identify appropriate candidates for salvage cryotherapy (26). Conversely, cases suggestive for spread of tumor beyond the prostate (including lymphadenopathy) may be less likely to benefit from cryotherapy (Figs. 35.9 and

35.10). MRI can also be performed after clinical failure of initial cryotherapy to assess for residual disease (Fig. 35.11).

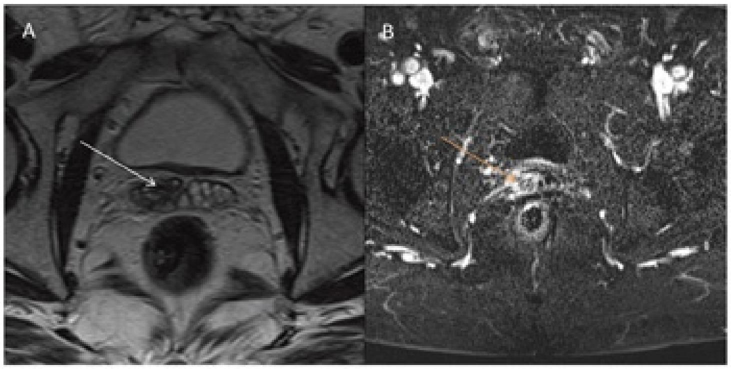

FIGURE 35.9 Axial T2W (**A**) and early phase DCE (**B**) images of a patient with tumor (*arrow*) in the right seminal vesicle after clinically ineffective salvage cryotherapy.

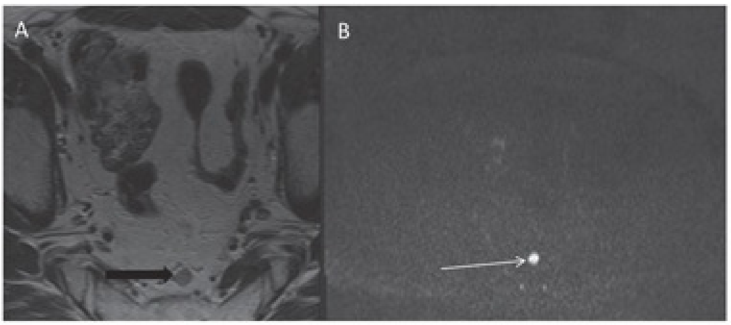

FIGURE 35.10 Axial T2W (**A**) and DW (**B**) images demonstrating a malignant perirectal lymph node (*arrow*) in a patient with a rising PSA following whole gland external beam radiotherapy.

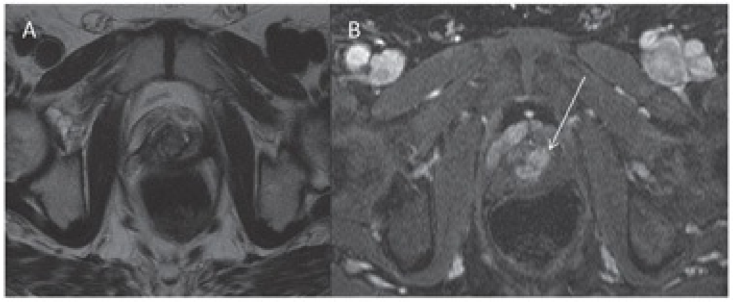

FIGURE 35.11 Axial T2W (**A**) and early phase DCE (**B**) images from a patient with persistent PSA elevation following salvage cryotherapy. Note the difficulty in visualizing the focus of tumor on T2W but ease of visibility on the contrast enhanced image (*arrow*). Also note the nontumor enhancement in the periurethral prostate (a typical finding following cryotherapy).

In conclusion, the field of MRI will likely continue to rapidly advance. High-quality research studies are still needed to better elucidate whether these techniques truly impact the clinical outcomes for patients. However, based on the clear improvement in the ability to identify foci of prostate tumor that may have been undiagnosed in the past, the likelihood is that prostate MRI will become an essential tool in the accurate risk assessment and staging of prostate cancer and may streamline treatment algorithms. The ability to accurately identify prostate cancer also opens up numerous possibilities for novel approaches to prostate cancer treatment that were not possible before.

FOCAL THERAPY FOR PROSTATE CANCER

One of the main motivating factors for the development of focal therapies is the notion that prostate cancer is overtreated. Since the introduction of prostate-specific antigen (PSA), the incidence of prostate cancer has increased dramatically, accompanied by a downward stage and grade migration of new cases (27,28). This has resulted in the diagnostic dilemma of whether traditional curative treatments that target the whole gland are necessary for what are predominantly low-risk cancers. Although such treatments—including radical prostatectomy and radiation—are effective, they are associated with significant side effects. On the other hand, although active surveillance for low-risk disease is well-established, safe, and effective—with cancer-free survival rates at 10 years exceeding

80% (29)—it is burdensome both physically and emotionally.

One of the main purported advantages of focal therapy is that injury to the organ is limited to areas harboring cancer, thereby sparing presumably noncancerous tissue and gland from side effects of that treatment. By treating localized tumors, and sparing the rest of the prostate along with the urethral sphincter and neurovascular bundles, the common side effects of whole gland therapies are minimized.

Cryotherapy

Of the multiple focal therapies available at present, cryotherapy is the most well-studied. In 2008 (and updated in 2009), the American Urological Association published their Best Practices guidelines, describing primary cryotherapy as an "option in selected patients" (30). Selection criteria included both disease-specific and patient-specific factors: Low and intermediate risk patients are most suitable (although high-risk patients are not excluded) as are patients who cannot (or do not wish to) undergo radical prostatectomy.

Cryobiology involves several mechanisms. Direct cellular injury results from ice crystal formation in the extracellular fluid, with subsequent movement of water from within the cell to the extracellular matrix, leaving the cell hyperosmolar. As the cell shrinks, the intracellular matrix, including its protein components, is disrupted. Eventually, ice crystals form within the cell and rupture the membrane. In addition, direct vascular injury and platelet-induced thrombosis compromise blood flow, resulting in ischemic damage. Additional proposed mechanisms of cell death include apoptosis, or programmed cell death, resulting from activation of various pathways and immune-mediated mechanisms (31,32).

Cryotherapy was first used in the 1960s: Cooling was achieved via liquid nitrogen-infused probes, and access to the prostate was done transurethrally or through an open perineal incision (33,34). At that time, no mechanism was used to protect adjacent structures, resulting in frequent injury to the rectum and external urethral sphincter (35). The technology gained greater acceptance in the 1990s when the introduction of transperineal probes and urethral warmers led to fewer complications (36,37). In addition, the replacement of liquid nitrogen with pressurized argon gas allowed for rapid freezing/warming in real time. The use of thermocoupling devices allowed for monitoring the temperature of the ice ball as well as of adjacent structures and for termination of the freezing cycle when the desired temperature (usually −40°C) was achieved.

In 2002, Onik and colleagues (38,39) first reported on the use of cryotherapy for prostate cancer in a group of 48 patients with clinically unilobar disease. At 2 years, 95% of patients had no biochemical recurrence (following ASTRO criteria), with no significant change in urinary symptoms and preservation of potency in 90% of patients who were potent preoperatively. More recently, Bahn and colleagues (40) reported on 70 patients with unilateral, low-intermediate risk disease. With a median follow-up of 3.7 years, matched pair analysis with patients undergoing radical prostatectomy showed similar "salvage-free" survival rates. Cohen et al. (41) has reported on the series with the longest median follow (12.6 years). In a total group of 370 patients, the 10-year negative biopsy rate was 77%, and biochemical recurrence-free survival ranged from 46% to 81% depending on initial risk stratification.

High-Intensity Frequency Ultrasound

High-intensity frequency ultrasound (HIFU) is a relatively novel technology that uses sound waves directed at tissue located at a specific distance from the emitting probe (42). Ablation occurs through heating of the targeted tissue as it absorbs energy from the sound waves and through cavitation, which describes the induction of oscillating microbubbles of water that result in dispersion of energy (43).

Ahmed and colleagues (44) were the first to conduct a trial using HIFU. The results of their phase I/II study in 2011 showed that 89% of 20 men attained the trifecta of being pad-free, potent, and with no histologic evidence of disease at 12 months (44). In a more recent report of 56 men with low-, intermediate-, and high-risk pathology found within an MRI-detected "index" lesion, short-term results were promising. Over 80% had no residual or recurrent disease on biopsy, and baseline urinary and sexual function was preserved in 92% and 77%, respectively (45).

Pros and Cons of Focal Therapy

Although focal ablative therapies are attractive due to their minimal invasiveness and potential reduction in side effects, they face several obstacles in gaining full acceptance as primary treatment. Although both cryotherapy and HIFU appear to be promising technologies, with good short- and intermediate-term disease-free survival rates along with reduced side effects, they have limitations. First and foremost, although the technology appears to be safe and efficacious, there is a dearth of long-term quality data on a large cohort of patients. Regarding patient selection, it is unclear who is best suited for these therapies. Nguyen and colleagues (46) have suggested that focal cryotherapy may be an alternative for patients considering active surveillance—that is, those with low-risk disease. In this context, focal therapy is seen as a compromise between active surveillance, which leaves the cancer untreated, and traditional curative techniques, which are associated with potential side effects (46,47).

One of the main concerns regarding focal therapy is that prostate cancer has long been considered to be *multi*focal. Indeed, in radical prostatectomy series, multifocality has been found in 67% to 87% of specimens (48). Therefore, ablating one or even several lesions detected on imaging may miss other tumor sites. A counter argument is that despite the multifocal nature of the disease, there is often an "index" lesion that harbors the most malignant potential (49). Therefore, treating this lesion may be sufficient, especially for lower grade and more indolent disease. Detection of the malignant lesion has also posed a challenge in the past. Although ultrasonography is notoriously inaccurate, improvements in MRI have led to positive predictive values of suspicious lesions (based on biopsy results) of more than 98% (50,51). However, the actual delivery of the ablative energy may be challenging in the case of anterior lesions, both for needle-based targeting using cryoablation and for HIFU.

Finally, a major deficiency in focal therapy is the fact that there is no true consensus on how to monitor patients after treatment for disease recurrence. To date, researchers have adopted similar criteria as for postradiation patients (e.g., ASTRO), but this has not been effectively validated.

Although obstacles do exist to the widespread acceptance of focal therapies, the push for treatments with fewer side effects but acceptable oncologic control will continue. If additional longer term data confirms the safety and efficacy of these technologies, they may replace traditional whole gland therapies for a subset of patients.

ADVANCED ROBOTIC SURGERY

With the rapid adoption of robot-assisted laparoscopic surgery within a decade of its introduction worldwide, there is significant interest in the development of alternative robotic platforms for urologic surgery. We review several advanced mechanisms for delivery of robotic surgery in urology.

Flexible Robot-Assisted Ureteroscopy

The initial use of flexible robotic-assisted techniques was in interventional cardiology, where the robot was used to facilitate transseptal puncture and endocardial catheter navigation (52). Like the heart, subtle manipulation of flexible instruments in the kidney is affected by breathing movements and lack of stability. Robotics has been proposed as a possible adjunct to traditional ureteroscopy, with the added benefit of removing the surgeon from the radiation source (53).

Hanson Medical System (Mountain View, California) devised the Sensei robotic system for ureteroscopy. The Sensei robotic system is similar to the da Vinci system used for surgical robotics as it is a master–slave system but has four unique components: (a) a surgeon console with an LCD screen and master input device (MID) (Fig. 35.12), (b) a remote table-mounted catheter manipulator (Fig. 35.13), (c) a steerable catheter system, and (d) an electronic rack. At the console, three LCD monitors display endoscopic, fluoroscopic, and other procedure-specific imaging and information. The MID is a joystick that the surgeon manipulates, and these movements are translated to the catheter tip. An outer catheter sheath (14Fr/12Fr) is first manually positioned, followed by an inner catheter guide (12Fr/10Fr) through which the steerable catheter is inserted. The workstation's remote positioning has the secondary advantage of decreasing radiation exposure to the operating surgeon.

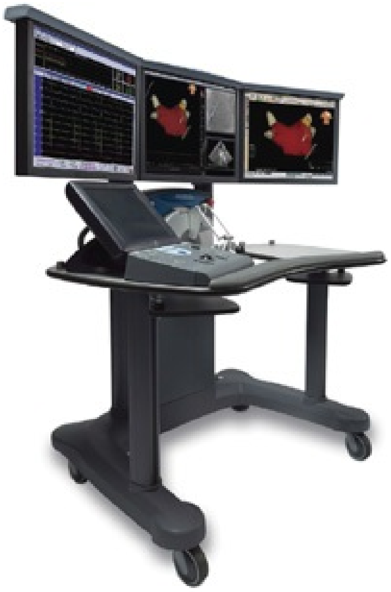

FIGURE 35.12 Surgeon console. (Courtesy of Hansen Medical Inc.)

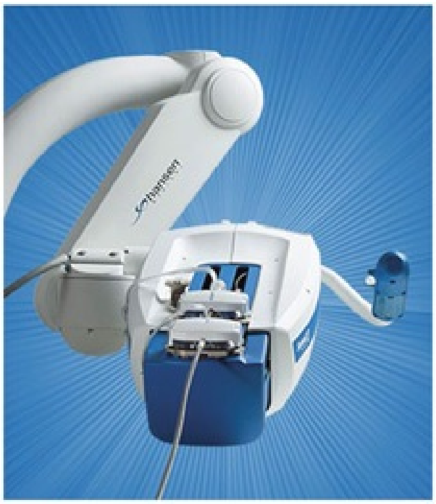

FIGURE 35.13 Table-mounted robotic manipulator. (Courtesy of Hansen Medical Inc.)

The feasibility of robotic ureterorenoscopy was demonstrated in both the porcine model (54) and in patients (55). Initial animal experience demonstrated remarkable tip stability as well as ease of manipulation with successful manipulation remotely into 83 of 85 calyces (98%). The human experience was similarly promising, with 18 patients with renal calculi ranging in size from 5 to 15 mm (mean stone size 12 mm) undergoing flexible robotic ureteroscopy. The flexible robotic catheter system was manually introduced into the collecting system over a guidewire under fluoroscopic control, but all subsequent intrarenal maneuvers, including stone relocation and fragmentation, were done exclusively from the robotic console. There were no conversions or intraoperative complications and the mean robotic time was 41 minutes with mean operative time totaling 91 minutes. Based on computerized tomogram/excretory urogram at 3 months, the complete stone clearance rate was 89%, and all patients had stable renal function and unobstructed drainage.

Natural Orifice Transluminal Endoscopic Surgery and Miniature Robots

Given the urologists’ familiarity with both endoscopic/endoluminal surgery and laparoscopic/extraluminal techniques, natural orifice transluminal endoscopic surgery (NOTES) has been of interest since the earliest published reports of this technique in 2004 (56). NOTES involves traversing intact hollow viscera (stomach, vagina, colon, bladder) to access intra-abdominal targets for ablative, extirpative, and reconstructive surgery. The proper instrumentation and entrance/exit strategies for NOTES vary by provider, and the early experience with this approach underscored the importance of improved instrumentation beyond traditional laparoscopy due to the complex movements required with NOTES.

Multiple approaches have been identified to address this concern. The da Vinci robotic platform has been used to perform a variety of transvaginal, transcolonic, and transgastric urologic procedures in animal models, including nephrectomy, pyeloplasty, and partial nephrectomy (57,58). Typically, a multichannel transumbilical port was used with an additional working arm placed transvaginally. The common complaint of external clashing of robotic arms limiting the range of motion has pushed surgeons to consider novel surgical tools, including flexible laparoscopic instruments. The first NOTES transvaginal nephrectomy was described by Haber and colleagues (58) in 2008 using a 5-mm umbilical port and a transvaginal GelPort containing two 5-mm trocars and one 12-mm trocar. They noted the necessity of flexible laparoscopy as well as long, articulating instruments to perform this procedure.

Another approach is to use task-specific miniature robots deployed in vivo inside the peritoneum, which without the typical constraints of an externally actuated flexible endoscopic device. Current miniature robotic prototypes are either fixed-base or mobile robots (59). Fixed-base robots are deployed and positioned and cannot self-navigate from their initial position. A pan-and-tilt camera, fashioned with LEDs for illumination, a 15-mm diameter conical design, spring-loaded tripod “legs,” and two independent motors controlling camera movement (pan 360 degrees, tilt 45 degrees). This camera was deployed through an abdominal incision and used in conjunction with standard laparoscopic equipment to facilitate porcine cholecystectomy (60). A second-generation tilting camera has been used in conjunction with a standard laparoscope for canine prostatectomy (59). This initial prototype is a “wired” camera for power input, and wireless prototypes are on the horizon (61,62).

In animal studies, a mobile camera has been used to provide sole visualization for abdominal exploration and cholecystectomy (63). In this case, the camera port was therefore unnecessary and the cholecystectomy was performed with two trocars. In another study, the mobile robotic platform has demonstrated the successful biopsy of three samples of hepatic tissue (64). For NOTES applications, successful remote-controlled exploration through a gastrotomy has been performed in the porcine model (65). This was monitored by the endoscopic rather than the robotic camera, but it successfully demonstrated proof of concept. The robot was then retracted into the gastric cavity, and the transgastric incision was closed using two endoclips and one endoloop. Also in pigs, the feasibility of using multiple miniature robots for improving spatial orientation and providing task assistance has been demonstrated. Three miniature in vivo robots, shown in Figure 35.14, including a peritoneum-mounted imaging robot, a lighting robot, and a retraction robot, were used in conjunction with a standard upper endoscope to demonstrate various capabilities for NOTES procedures.

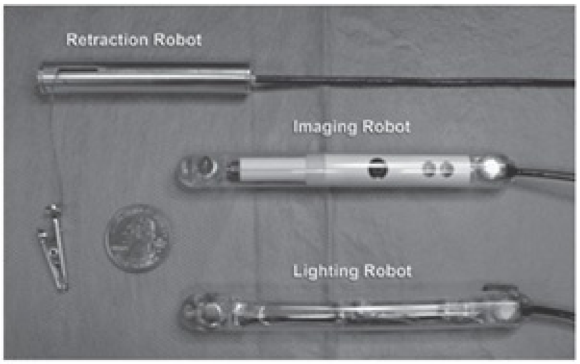

FIGURE 35.14 Miniature in vivo robots. (Photo courtesy of Dr. Dmitry Oleynikov, University of Nebraska Medical Center, Omaha, NE.)

As task-specific robotic systems progress in development, flexible robotics, NOTES surgery, and in vivo miniature robots are likely to transform our concept of minimally invasive surgery in the coming decades as endourology, laparoscopy, and robotic surgery has in the prior ones.

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SECTION IV■ URETHRA

Section Editor: ERIC S. ROVNER

CHAPTER 36■ANATOMY OF THE URETHRA

LAWRENCE M. DAGROSA AND E. ANN GORMLEY

FEMALE URETHRA

Gross/Microscopic

The female urethra extends 3 to 5 cm from the bladder neck to the external urethral meatus. This fibromuscular tube from the lumen outward is composed of a mucosal lining, a submucosal layer, and a muscular layer. The proximal urethra is lined with transitional cell mucosa and is continuous with the bladder urothelium. Distally, the mucosa transitions to nonkeratinized stratified squamous epithelium (Fig. 36.1). The submucosa consists of abundant longitudinal and circular elastic fibers and contains a prominent venous system. The engorgement of this venous plexus decreases the luminal diameter of the urethra creating a hermetic seal, which has been reported to account for up to 33% of urethral closing pressure (1,2). Historically, it has been described that these veins are hormone-sensitive and their relative volume has been shown to decrease with age, likely adding to the age-related decrease in urethral closing pressure seen in the postmenopausal population (3). Colleselli and others (4) have shown that in the proximal third and most of the middle third of the urethra, there are three smooth muscle layers, including outer and inner longitudinal layers and a middle transverse or circular layer. These muscles are continuous with the bladder neck proximally and terminate distally in the subcutaneous tissue surrounding the external urethral meatus, intermingling with the striated muscle fibers of the rhabdosphincter. In fetal specimens, the smooth muscle layer is more defined distally, whereas this layer is thin or absent in the distal urethra of the adult (4). The density of urethral circular smooth muscle decreases with age, which may also contribute to the decrease in urethral closure pressure and incontinence associated with increasing age (5).

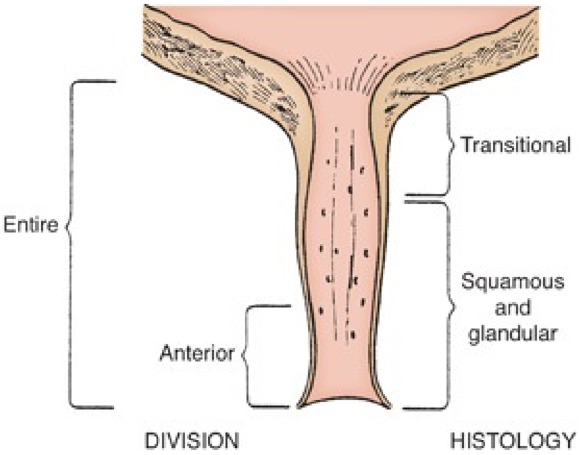

FIGURE 36.1 The female urethra.

In the distal two-thirds of the urethra, a layer of striated muscle, the rhabdosphincter, surrounds the smooth muscle layer, on the dorsal and lateral aspects making an omegalike-shaped sphincter (4). The rhabdosphincter is composed of delicate type I (slow-twitch) fibers and consists of three distinct muscles. Proximally, the muscle forms a ring (sphincter urethrae) that encircles the urethra. Distally, the muscle (compressor urethrae) fans out laterally along the curve of the inferior border of the pubic rami to compress the urethra against the anterior vaginal wall. At the vestibule, the muscle completely surrounds the urethra and vagina to form a urethrovaginal sphincter (Fig. 36.2) (6). The three muscles work together to provide constant urethral tone (Fig. 36.3) (7). Normally, the striated sphincter plays a minimal role in resisting abdominal pressure. However, preservation of the rhabdosphincter is necessary for continence after creation of a female neobladder (4).

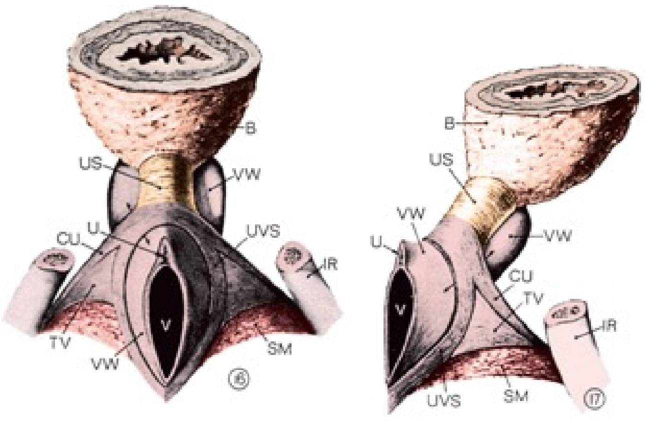

FIGURE 36.2 Striated urogenital sphincter muscle seen from below after removal of the perineal membrane and pubic bones. *US*, urethral sphincter; *UVS*, urethrovaginal sphincter; *CU*, compressor urethrae; *B*, bladder; *IR*, ischiopubic ramus; *TV*, transverse vaginae muscle; *SM*, smooth muscle; *U*, urethra; *V*, vagina; *VW*, vaginal wall. (Reprinted with permission from Oelrich TM. The striated urogenital sphincter muscle in the female. *Anat Rec* 1983;205:223. Copyright © 1983 Wiley-Liss, Inc, a Wiley Company.)

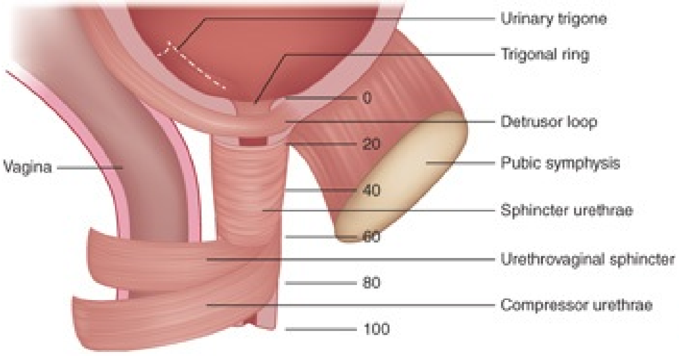

FIGURE 36.3 Location of various structures along the urethra. Note the three parts of the rhabdosphincter.

There are numerous small periurethral mucous glands that run along the length of the urethra and open into small recesses in the mucosa. Paired periurethral (Skene) glands drain on either side of the midline just posterolateral to the urethral meatus.

Vascular Anatomy

The arterial supply to the female urethra is from the urethral artery, a branch of the internal pudendal artery, which in turn is a branch of the internal iliac artery (8). The venous drainage is via the pelvic venous plexus.

Innervation

The smooth muscle of the urethra is innervated by parasympathetic nerves. The predominant sympathetic receptors are alpha-adrenergic (9). These receptors are responsible for urethral smooth muscle contraction and possibly engorgement of the submucosal vasculature to create a watertight seal of the urethral mucosa (10). The striated muscle fibers of the rhabdosphincter receive innervation from the pudendal and pelvic somatic nerves (11). Both somatic and autonomic nerves to the urethra travel on the lateral walls of the vagina near the urethra. Various authors have advised against dissection in this area during transvaginal surgery to prevent development of stress urinary incontinence due to intrinsic sphincter dysfunction (12).

Lymphatics

The lymphatic drainage of the proximal urethra is to the deep pelvic lymph nodes. The drainage of the distal portion of the urethra is to the inguinal nodes.

Contiguous Structures

A “hammock” of vaginal tissue supports the urethra (13). Although the exact nomenclature is contested in the literature, the urethral supports, also termed “pubourethral ligaments,” include fascial and muscular attachments to the arcus tendineus fasciae pelvis and levator ani muscles. These supports are only present in the distal third of the urethra. It has been postulated that they “fix” the urethra to the pubic bone; however, there is conflicting anatomic data that suggests the bladder, urethra, and the anterior vaginal wall are freely mobile (14). The pubovesical muscle is a separate structure that is an extension of the smooth muscle of the bladder, which extends from the detrusor muscle to the arcus tendineus fasciae pelvis and pubic bone (Fig. 36.4) (15).

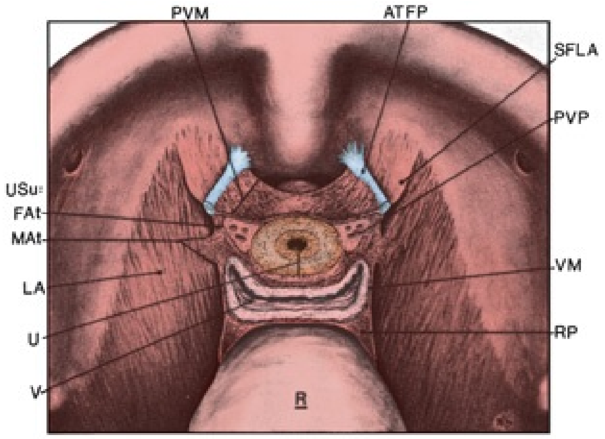

FIGURE 36.4 Cross section of the urethra (*U*), vagina (*V*), arcus tendineus fasciae pelvis (*ATFP*), and superior fascia of levator ani (*SFLA*) just below the vesical neck (drawn from cadaver dissection). Pubovesical muscles (*PVMs*) lie anterior to urethra and anterior and superior to paraurethral vascular plexus (*PVP*). The urethral supports (*USu*) (the pubourethral ligaments) attach the vagina and vaginal surface of the urethra to the levator ani muscles (*MAt*, muscular attachment) and to the superior fascia of the levator ani (*FAt*, fascial attachment). *LA*, levator ani; *R*, rectum; *RP*, rectal pillar; *VM*, vaginal wall muscularis. (Reprinted with permission from DeLancey JOL. The pubovesical ligament, a separate structure from the urethral supports. *Neurol Urodynam* 1989;8:53. Copyright © 1989 Wiley-Liss, Inc, a Wiley Company.)

The urethra is intimately related to the anterior surface of the vagina for the distal two-thirds of its course (16). The periurethral fascia is located immediately beneath the vaginal wall and is seen as the glistening white layer that surrounds the urethra when an incision is made in the anterior wall of the vagina. The fascia extends from the meatus to the bladder neck and laterally to where it fuses with the endopelvic fascia at the pubic bone (Fig. 36.5).

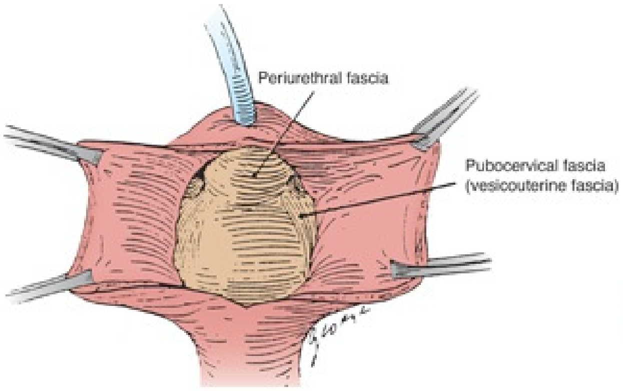

FIGURE 36.5 View of the anterior vaginal fascial support, which is found beneath the vaginal wall (shown retracted). The periurethral fascia, which forms the vaginal layer of the urethropelvic ligaments, is continuous with the pubocervical fascia proximally.

MALE URETHRA

Gross/Microscopic

The posterior urethra extends from the bladder neck, through the prostate, to the urogenital diaphragm. It is divided into the prostatic urethra and the membranous urethra, which traverses the urogenital diaphragm just prior to entering the corpora spongiosa. The anterior urethra runs from the urogenital diaphragm to the tip of the glans penis and may be further divided into the bulbous urethra, extending from the root of the penis to the convergence of the corpora cavernosa, and the pendulous or penile urethra that traverses the pendulous portion of the penis. There is a dilation of the urethra in the area of the glans penis called the fossa navicularis (Fig. 36.6).

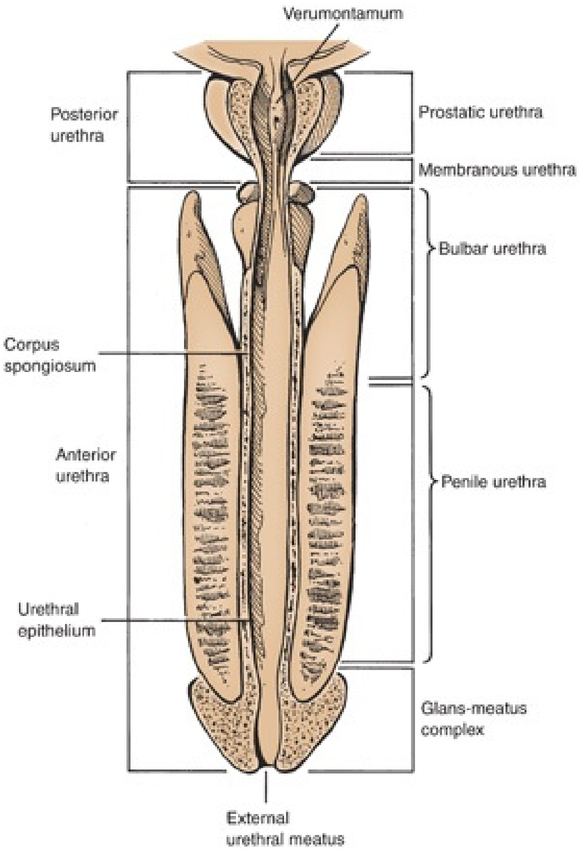

FIGURE 36.6 The male urethra and its divisions with associated histology.

A number of ducts empty into the lumen of the urethra. The orifices of the paired bulbourethral (Cowper) glands are found on the floor of the pendulous urethra, 2 to 3 cm distal to the membranous urethra. On the roof of the pendulous urethra, there are openings for the glands of Littre, or the submucosal urethral glands, and small recesses termed *urethral lacunae*. The lacuna magna is a larger lacuna in the midportion of the anterior aspect of the fossa navicularis.

The urethral epithelium varies along the length of the urethra. In the prostatic urethra, the cells are transitional, whereas in the membranous urethra, they are stratified columnar. The epithelium of the penile urethra is composed of pseudostratified and columnar cells. In the fossa navicularis, the epithelium is composed of stratified squamous cells.

Vascular Anatomy

Paired bulbourethral arteries, which arise as the first of three penile branches of the internal pudendal artery, supply the urethra. The venous drainage is via the emissary veins, which drain to the circumflex branches of the deep dorsal vein of the penis.

Innervation

The urethral mucosa is innervated via the urethrobulbar nerve. It is a branch of the nerve to the bulbocavernosus, which is a branch of the perineal nerve derived from the pudendal nerve. A branch of the bulbocavernosus nerve at the 3 and 9 o'clock positions penetrate the striated urethral sphincter (17). The pudendal nerve, consisting of fibers from the second, third, and fourth sacral spinal nerves, is thus both motor to the urethral sphincter and sensory to the urethra and glans penis.

Lymphatics

The lymphatic drainage of the anterior urethra is into the superficial and deep inguinal nodes and ultimately to the external iliac nodes. The lymphatics of the posterior (the bulbous, membranous, and prostatic) urethra can take three routes: to the external iliac nodes, to the obturator and internal iliac nodes, or to the presacral nodes.

Contiguous Structures

The membranous urethra is covered by the fibers of the striated urethral sphincter (rhabdosphincter). Brooks et al. (18) used computer-generated, three-dimensional reconstruction of the male pelvis from the visible human data set to show that the striated urethral sphincter is circular with abundant posterior tissue, making it more singet ring–shaped. Anteriorly and laterally, the rhabdosphincter is separated from the membranous urethra by a thin sheath of connective tissue (19). Anteriorly, the sphincter is approximately twice as long as it is posteriorly. An intrinsic smooth muscle lies between the urethral mucosa and the striated urethral sphincter. This muscle begins above the striated sphincter and then gradually thins distal to the striated sphincter (18).

The remainder of the anterior urethra lies within the corpus spongiosum, lying in the ventral groove of the corpora cavernosa of the penis. The Cowper glands (bulbourethral glands) lie within the urogenital diaphragm posterior and lateral to the membranous urethra.

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CHAPTER 37 FEMALE URETHRAL RECONSTRUCTION FOR FISTULA AND FEMALE URETHRAL DIVERTICULUM

AHMED M. EL-ZAWAHRY AND ERIC S. ROVNER

Female urethral problems can be debilitating and disturbing to the quality of life in women secondary to problems affecting voiding or devastating incontinence. Reconstruction of the female urethra is technically demanding. Understanding the surgical principals is critical to optimize outcomes. The goal of surgery is to reconstruct the urethra and to obtain a functional urethra that enables the patient to void volitionally and be socially continent. Urethra fistula and urethral diverticula, although both relatively uncommon, are probably the two most common conditions of the female urethra requiring major reconstruction.

RECONSTRUCTION OF THE FEMALE URETHRA FOR FISTULA

In the developing world, the major causes of the development of urethral fistula are related to obstetric trauma secondary to prolonged labor. This is responsible for the development of about 90% of urinary fistula in women (1). In contrary, in the developed world, urethral damage is most commonly iatrogenic. This can occur secondary to (a) transvaginal surgery such as transvaginal urethral diverticulectomy, bladder neck suspension, anterior colporrhaphy (2), or vaginal hysterectomy (Table 37.1); (b) complications caused by erosion of synthetic materials placed during pelvic reconstructive surgery or midurethral sling procedures (2); (c) obstetric complications from instrumentation during vaginal delivery, such as cerclage sutures (2); (d) prolonged indwelling urethral catheter in neurogenic disorders; (e) locally invasive malignancies and long-term effects of radiation (3); and (f) pelvic trauma resulting in laceration of the urethra (4).

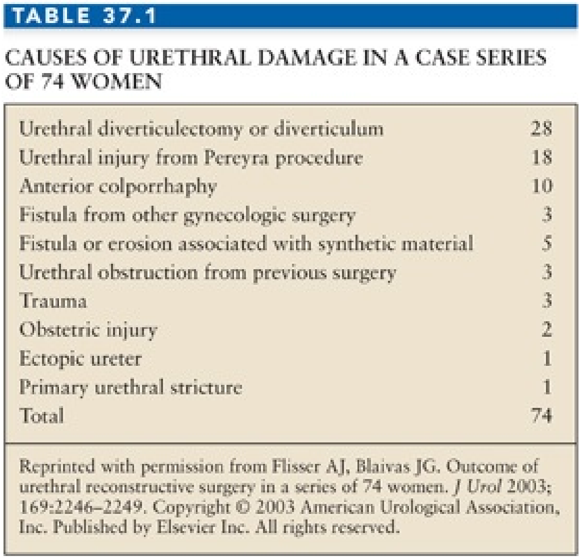

TABLE 37.1

CAUSES OF URETHRAL DAMAGE IN A CASE SERIES OF 74 WOMEN

Urethral diverticulectomy or diverticulum	28
Urethral injury from Pereyra procedure	18
Anterior colporrhaphy	10
Fistula from other gynecologic surgery	3
Fistula or erosion associated with synthetic material	5
Urethral obstruction from previous surgery	3
Trauma	3
Obstetric injury	2
Ectopic ureter	1
Primary urethral stricture	1
Total	74

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Diagnosis

In patients with urethrovaginal fistula, presentation depends on the location of the fistula. Distal urethrovaginal fistula may be asymptomatic, or the patient may present with vaginal voiding or splitting and spraying of urinary stream. Urethrovaginal fistula proximal to the sphincter can present with urinary incontinence.

A thorough history and physical examination are critical for evaluating a patient with suspected urethral fistula. The causes of the urethral problems need to be identified because it may impact the choice of surgery. Proper pelvic examination using suitable light and a speculum is important to identify the site of injuries or fistula, size, proximity to the bladder neck and urethral sphincter, and ureters. Any concomitant and adjacent injuries should be identified. The vaginal walls should be properly inspected for urine leak, and the quality of adjacent local tissue and the vaginal wall that could be used for reconstruction should be assessed.

Cystoscopy should be considered to help identify the location of the fistula relative to the bladder neck and sphincter and the extent of the pathology. If there is difficulty in identifying the fistula, vital dye such as indigo carmine diluted in saline could be used during cystoscopy or infused through a partially inflated Foley catheter in order to localize the fistula. Cystoscopy may also help to rule out the presence of any other concomitant pathology.

Radiographic imaging may be helpful to assess the integrity of the rest of the urinary tract. Abdominal and pelvic computerized tomography with intravenous contrast can help to identify concomitant injuries. Cystogram and voiding cystourethrogram (VCUG) may be helpful if bladder injury is suspected or to further identify the location of the fistula or the length of associated urethral stricture. Retrograde pyelography or other upper tract imaging can be performed when ureteral injury is suspected (2,5).

Videourodynamic (VUD) examination should be considered in patients with coexisting lower urinary tract symptoms or symptoms suggestive of bladder neck injury. VUD helps to diagnose problems with bladder function such as the presence detrusor overactivity, abnormal bladder compliance, bladder capacity, bladder outlet obstruction, ureteral reflux, and urethral stricture and can identify concurrent vesical fistulas or diverticula.

Indications for Surgery

Surgical repair of the injured urethra should be considered in any symptomatic patient able and willing to undergo surgery. Other considerations during planning for surgical correction of the damaged urethra include (a) an autologous fascial pubovaginal sling may be considered during urethral reconstruction to help with incontinence; (b) a vascularized flap may be used in patients with history of radiation or extensive scarring to help with the poor quality of tissue and assist with healing; and (c) in patients with a small bladder capacity or low compliance, other procedures can be considered such as augmentation cystoplasty to improve vesical compliance and/or capacity.

The timing of surgery to repair fistula is variable. Historically, it was recommended to delay repair in iatrogenic fistula for 3 to 6 months to allow inflammation and edema of the local tissues to subside. This was felt to improve the quality of the tissue and render the tissue more pliable for repair. However, often this delay is not necessary, especially if physical examination reveals healthy pliable local tissues with minimal edema and inflammation. In such cases, surgical repair can be planned without the need to waiting. For obstetric fistula, where the injury is likely to be ischemic in origin, it is still preferable to wait 2 to 6 months to allow for demarcation of devitalized tissue to maximize likelihood of the success of the repair.

Alternative Therapy

Alternatives to urethral reconstruction for fistula include observation for asymptomatic individuals, or indwelling catheterization and supravesical urinary diversion for symptomatic patients. Chronic indwelling catheterization is an option especially if patients are unable or unwilling to undergo surgery. However, long-term indwelling catheterization is associated with complications such as infections, stones, detrusor dysfunction, possible urethral erosions, ostitis pubis, urothelial metaplasia, and a risk of development of squamous cell cancer. In some patients with radiation-induced urethral damage, a urinary diversion should be discussed because it may be the best long-term option.

Surgical Technique

Certain well-accepted general principles should be followed during reconstructive surgery of the urethra (Table 37.2). Rotational vaginal wall flaps are often adequate for repair. In addition, in some cases, alternative well-vascularized pedicle flaps assist with healing and prevent recurrent fistula formation especially with extensive scarring or history of radiation therapy. The available sites for flap harvest include the labia majora (6), the rectus abdominis muscle (7), gracilis myocutaneous (8), or perineal artery axial fasciocutaneous (Singapore) flaps (9).

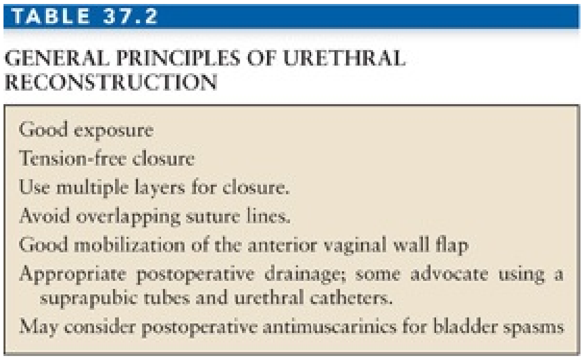

TABLE 37.2

GENERAL PRINCIPLES OF URETHRAL RECONSTRUCTION

Good exposure
Tension-free closure
Use multiple layers for closure.
Avoid overlapping suture lines.
Good mobilization of the anterior vaginal wall flap
Appropriate postoperative drainage; some advocate using a suprapubic tubes and urethral catheters.
May consider postoperative antimuscarinics for bladder spasms

For reconstruction, the patient is placed in the dorsal lithotomy position and then cystourethroscopy is performed to identify the location and extent of the damage. If the fistula is high and close to the trigone, then the ureteral orifices are visualized and the ureters may be catheterized to help with identification during surgery. If a suprapubic tube placement is planned, then the site is marked and a suprapubic cystostomy tube is placed under direct visualization unless concurrent abdominal incision is anticipated in which case the suprapubic tube is placed as part of the abdominal procedure.

The choice of surgery is variable and depends on (a) the location and size of the defect and (b) the availability of local tissue for flaps (10).

1. Small urethral defects: A tension-free *primary closure* (Fig. 37.1) is often adequate for small urethral defects. A 14Fr or 16Fr urethral catheter is placed, and the balloon is inflated. The vaginal wall around the fistula is marked and then hydrodissected using sterile saline. The vaginal wall around the fistula is dissected to mobilize a vaginal flap to help with closure (alternatively an inverted U-shaped incision is used). Then the periurethral fascia is dissected and mobilized to expose the urethra. The urethra is closed primarily with interrupted 4-0 or 5-0 absorbable sutures. It is often not necessary to excise the epithelium of the fistulous wall because such tissue can often be mobilized and used as a first layer of closure. This avoids increasing the size of the fistula. The periurethral fascia is then closed over the repair in a perpendicular direction to minimize overlapping of the suture lines. The vaginal wall is then advanced beyond the fistula repair and secured with absorbable sutures ensuring a lack of overlapping suture lines.

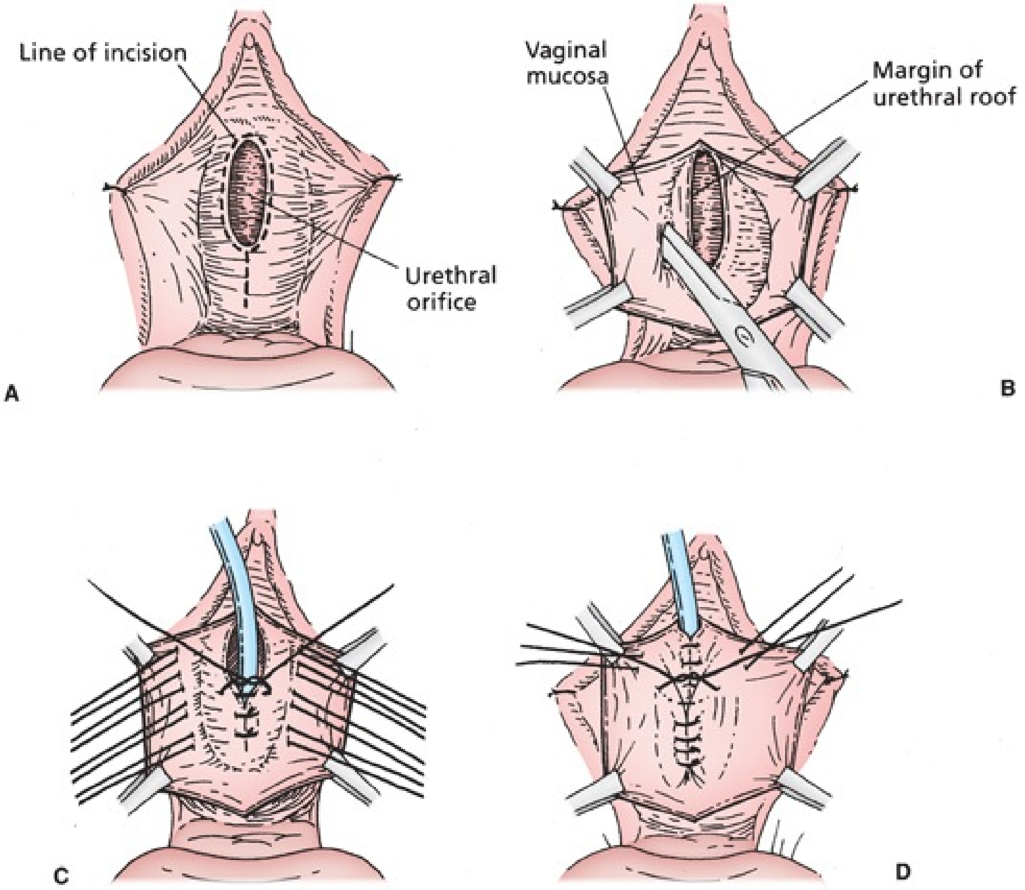

FIGURE 37.1 Primary closure. **A:** The fistula is circumscribed. **B:** Hydrodissection and then the lateral vaginal wall flaps are developed, and the lateral urethral walls are mobilized and freed. **C:** The urethra is closed primarily with interrupted tension-free watertight 4-0 or 5-0 absorbable sutures around a 14Fr catheter. **D:** The vaginal wall is closed primarily if possible or through mobilizing a U-shaped flap trying to avoid overlapping suture lines. (Modified from Mattingly RF, Thompson JD, eds. *Telinde's Operative Gynecology*, 6th ed. Philadelphia: JB Lippincott Co, 1985:662.)

2. Obliterated distal urethral tissue: A U-shaped *advancement anterior vaginal flap* (Fig. 37.2) is used if the distal urethral is obliterated and no sufficient urethral tissue exists for primary closure. Bilateral parallel incisions are made on the vaginal wall distal to the proximal urethra to the site of the urethral meatus. A flap is dissected of the anterior vaginal wall, advanced, and rotated 180 degrees and is sutured to the incisions on the distal vaginal wall to form the posterior and lateral walls of the neourethra. The urethra is closed over a 14Fr urethral catheter using 4-0 or 5-0 absorbable sutures. The vaginal wall is then advanced and closed primarily.

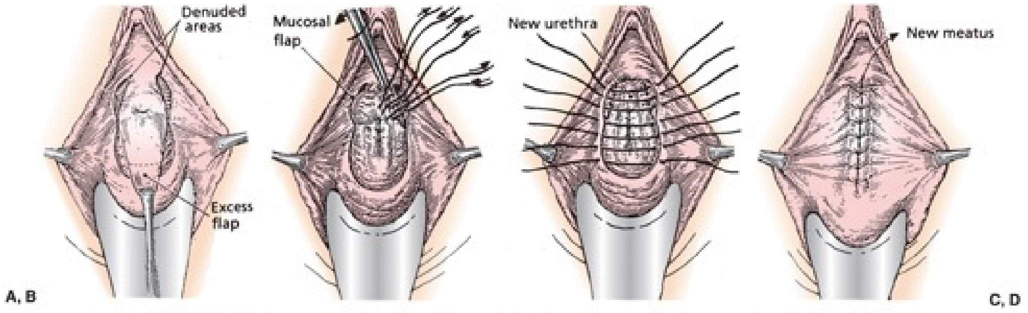

FIGURE 37.2 Advancement flap. **A:** A U-shaped incision is made with the arms of the U extending caudally as far as the planned urethral meatus. **B:** The flap is elevated and rotated 180 degrees. **C:** The flap is sutured to the edges of the parallel distal incisions over the catheter to form the new urethra. **D:** The vaginal wall is closed either primarily or with a U-shaped flap, depending on the availability of local tissue. (Modified from Mattingly RF, Thompson JD, eds. *Telinde's Operative Gynecology*, 6th ed. Philadelphia: JB Lippincott Co, 1985:660–661.)

3. Extensive loss of urethral tissue: A vaginal wall flap can be employed, as a *tube flap* (Fig. 37.3), as another available option in the setting of extensive loss of urethral tissue. A wide rectangular area (about 2.5 cm × 3.5 cm) is marked on the vaginal wall at the location of the distal urethra. Incisions

are made and then the rectangular vaginal wall flap is mobilized and fashioned into a tube over a 14Fr urethral catheter using 4-0 or 5-0 absorbable sutures. The tube is then connected to the proximal urethra and to the site of urethral meatus using 3-0 absorbable sutures. In this situation, a pubovaginal sling is often used to achieve continence. A rotational flap of the vaginal wall is then mobilized to close the gap of the vaginal wall.

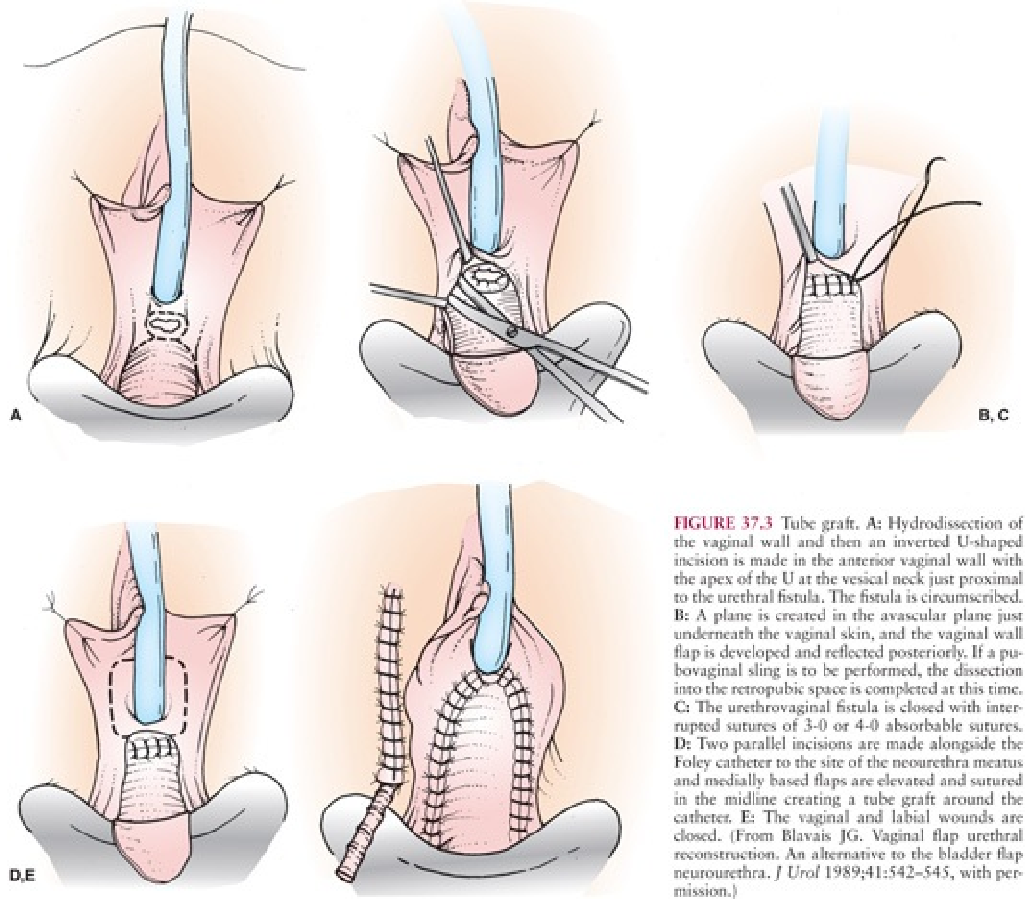

FIGURE 37.3 Tube graft. A: Hydrodissection of the vaginal wall and then an inverted U-shaped incision is made in the anterior vaginal wall with the apex of the U at the vesical neck just proximal to the urethral fistula. The fistula is circumscribed. B: A plane is created in the avascular plane just underneath the vaginal skin, and the vaginal wall flap is developed and reflected posteriorly. If a pubovaginal sling is to be performed, the dissection into the retropubic space is completed at this time. C: The urethrovaginal fistula is closed with interrupted sutures of 3-0 or 4-0 absorbable sutures. D: Two parallel incisions are made alongside the Foley catheter to the site of the neourethra meatus and medially based flaps are elevated and sutured in the midline creating a tube graft around the catheter. E: The vaginal and labial wounds are closed. (From Blavais JG. Vaginal flap urethral reconstruction. An alternative to the bladder flap neurourethra. *J Urol* 1989;41:542–545, with permission.)

4. Extensive urethral damage and insufficient vaginal wall: A *labia minora pedicle flap* (Fig. 37.4) is best suited for patients with this problem. A rectangular flap 3 cm × 3.5 cm is marked on the labium and then it is incised close to the site of the urethral reconstruction and mobilized. A tunnel is created under the vaginal wall and the labium flap is then mobilized with its vascular pedicle and underlying fat and is passed beneath the vaginal wall to the site of the urethra. The flap is then fashioned around a 14Fr catheter in a tension-free manner so that the mucosal surface is facing inward to form the lumen of the future urethra. The vaginal wall is then closed. A Penrose drain is placed in the labial harvest site for 24 hours and the labial skin is closed with 3-0 absorbable sutures. The Foley catheter is left to gravity for 10 to 14 days.

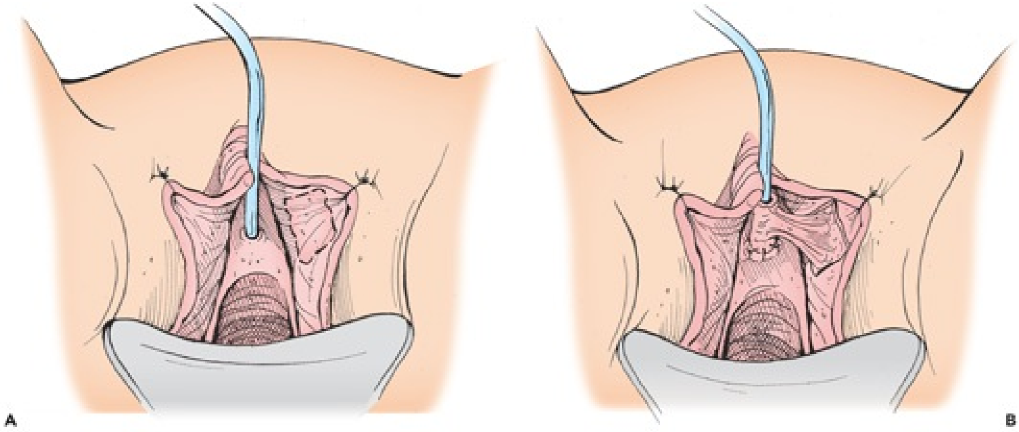

FIGURE 37.4 Labia minora pedicle graft. **A:** A rectangular incision 3.5 cm × 2.5 cm in the labia minora after hydrodissection is made and then the labial tissue and underlying fat is mobilized on the vascular pedicle. **B:** The flap is passed through a tunnel created under the wall of the labial skin to the site of the neourethra and sutured into position with the mucosal surface of the labia becoming the lumen of the neourethra.

5. Extensive urethral damage and extensive vaginal wall scarring: An anterior bladder flap can be used as an alternative to a vaginal wall flap in case of extensive vaginal scarring and vaginal wall loss secondary to a large urethrovaginal fistula that precludes using vaginal flaps. However, in this case, a concomitant anti-incontinence procedure should be strongly considered (6) (Fig. 37.5).

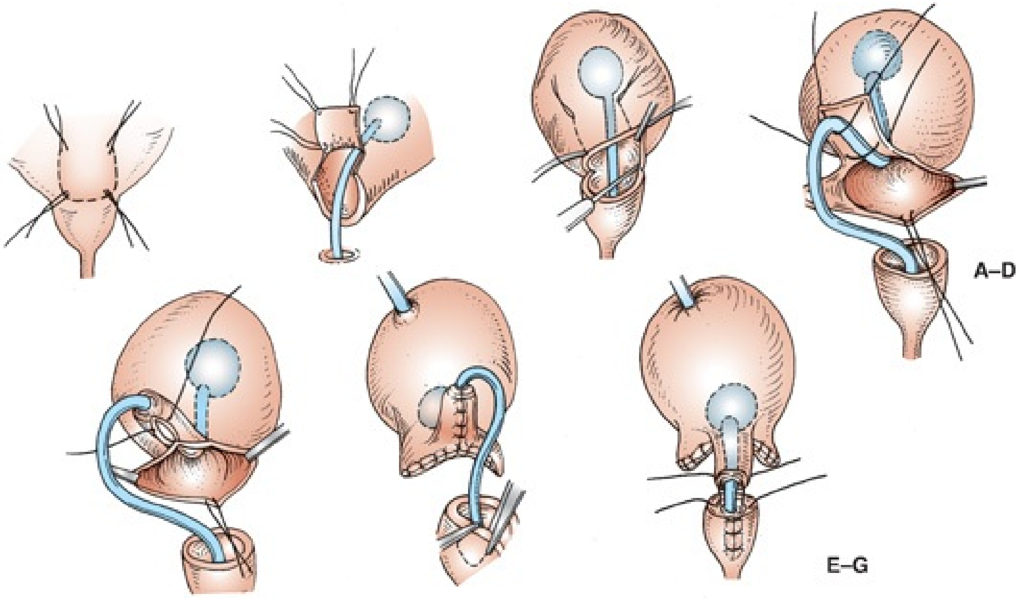

FIGURE 37.5 Bladder flap reconstruction. Tanagho anterior bladder flap reconstruction can be used in lieu of vaginal flap reconstruction. **A–D:** The bladder flap is marked on the anterior bladder wall with stay sutures. A full thickness of the bladder wall is cut and formed into a tube around a 16Fr urethral catheter. **E–G:** The bladder wall is sutured around the catheter using 3-0 or 4-0 absorbable sutures. The neourethra is then fixed to site of the urethral meatus. (Reprinted with permission from Tanagho EA. Bladder neck reconstruction for total urinary incontinence: 10 years of experience. *J Urol* 1981;125:321. Copyright © 1981 American Urological Association, Inc. Published by Elsevier Inc. All rights reserved.)

The edges of the fistula are freed by sharp dissection from the pubic rami. Next, the bladder is freed anteriorly and inferiorly from its attachments. A 4 cm × 2.5 cm rectangular flap is mobilized from the anterior bladder wall and fashioned into a tube around a 14Fr catheter using 4-0 or 5-0 absorbable sutures. The distal end of the tube is then fixed to the site of the new urethral opening in the original site. The neourethra is then fixed to the subcutaneous tissue or the periosteum of the pubic bone. A Martius flap can be performed to separate the overlapping suture lines (6).

An anti-incontinence procedure is advisable as a part of the reconstruction of the urethra to minimize the risk of postoperative incontinence. An autologous pubovaginal sling is the procedure of choice because the use of synthetic materials is not recommended due to the risk of erosion of the synthetic graft (11). It is important to avoid placing the pubovaginal sling until the urethra is completely reconstructed (Fig. 37.6). After placement of the autologous pubovaginal sling, a vascular pedicle graft (Martius flap) is often positioned between the pubovaginal sling and reconstructed urethra (Fig. 37.7). The vaginal wall is then closed, and at the conclusion of the operation, the long ends of the sling are tied together in the midline over the rectus fascia without tension.

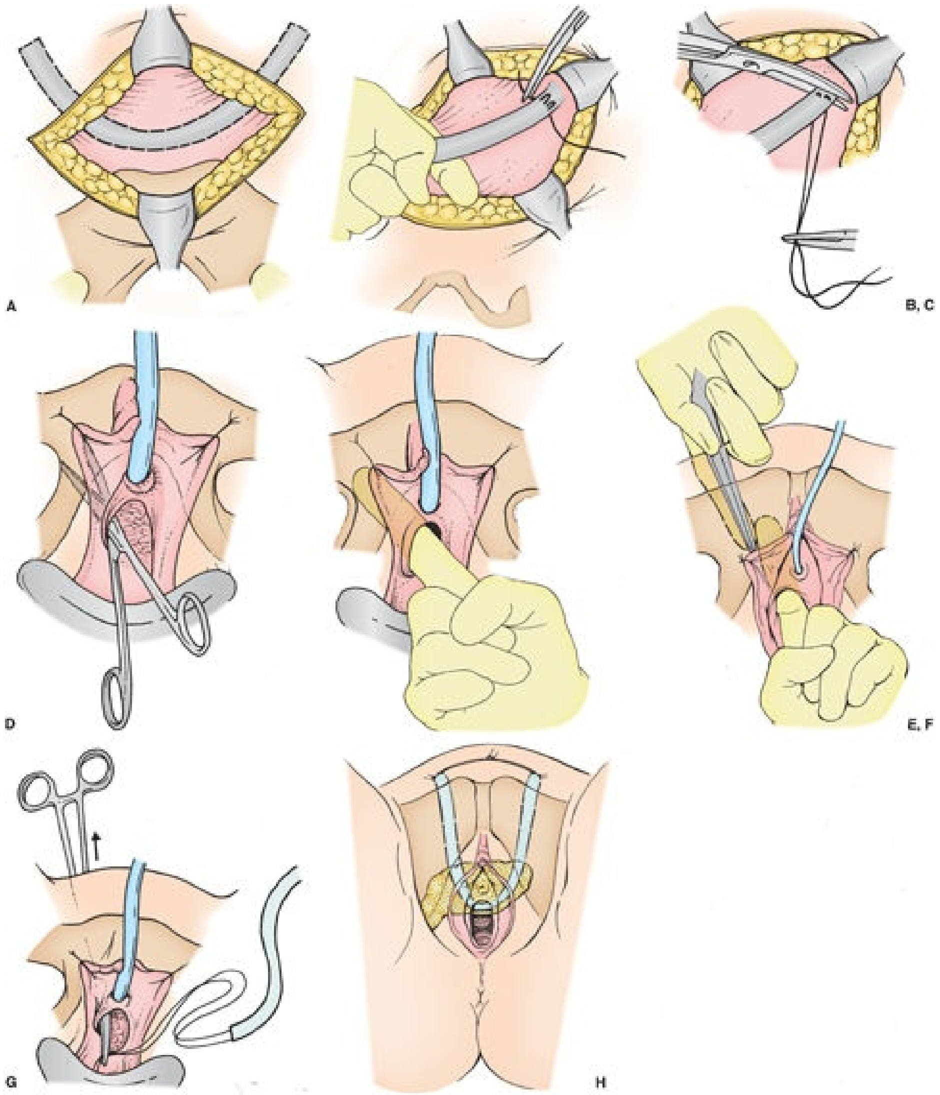

FIGURE 37.6 Pubovaginal sling. **A:** A lower abdominal Pfannenstiel incision is made at the skin crease, and dissection is carried out to the level of the rectus fascia. A 2 to 3 cm wide and 8 cm to 10 cm in length graft is outlined with the incision kept parallel to the direction of the fascial fibers. **B:** A 2-0 nonabsorbable running horizontal mattress suture is placed across the most lateral portion of the graft, and the ends are left long. **C:** Each end of the fascial graft is transected approximately 1 cm lateral to the mattress suture. **D:** Transvaginally, dissection is begun with Metzenbaum scissors in the avascular plane just beneath the vaginal skin. **E:** The endopelvic fascia is perforated with Mayo scissors with the tips of the scissors directed toward the patient's ipsilateral shoulder and ensure the tip of the scissors are marching on the posterior aspect of the pubic bone until the retropubic space is entered. **F:** A Pereyra-Raz ligature carrier or a long tonsil clamp is passed from the abdominal to the vaginal wound lateral to the urethra while protecting the urethra with a finger to bring one end of the graft to the abdominal incision. **G:** The fascial graft is passed around the urethra and brought to the abdominal wound. **H:** The long ends of the sling are tied together in the midline under no tension. The labial fat pad, if used, is positioned between the sling and the vesical neck. (A–G from Blavais JG. Pubovaginal sling procedure. In: Whitehead ED, ed. *Current Operative Urology*. Philadelphia: JB Lippincott Co, 1990:93–101, with permission.)

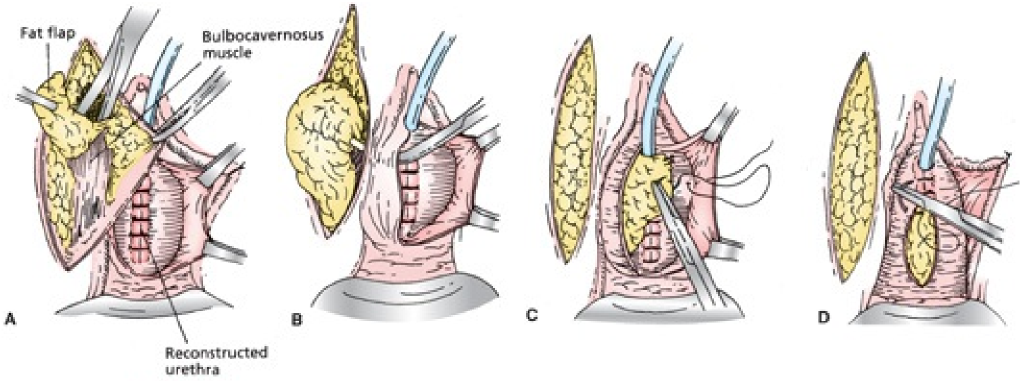

FIGURE 37.7 Vascular pedicle graft (Martius flap). **A:** Incisions in skin crease of the labia majora to expose the underlying fat pad, the blood supply to the superior margin is controlled with suture ligation and then the flap is mobilized posteriorly. **B:** The flap is tunneled under the skin to the vaginal incision. **C:** The flap is fixed over the reconstruction site at two sites with 3-0 or 2-0 absorbable sutures. **D:** The vaginal wall is closed over the reconstruction, and the flap and the donor site is inspected for any bleeding and then closed. If a pubovaginal sling is performed, it is placed beneath the vaginal wall prior to the closure. (Modified from Mattingly RF, Thompson JD, eds. *Telinde's Operative Gynecology*, 6th ed. Philadelphia: JB Lippincott Co, 1985:663.)

A VCUG is obtained through the suprapubic catheter about 2 weeks after the procedure. If the patient successfully voids with no extravasation, the suprapubic catheter can be removed.

Outcomes

Results

Reconstruction of female urethra has been reported to be successful in 67% to 100% of cases. Improved outcomes are noted using vascular pedicle flaps especially in patients with history of fistulae secondary to radiation therapy and in patients with extensive scarring (12,13). Continence can be achieved in 55% to 93% of patients after reconstruction with proper surgical techniques. Continence outcomes are improved with using an anti-incontinence pubovaginal sling procedure. Urethral obstruction can also occur after reconstruction in 2% to 41% which may require additional procedures. Overall functional success of urethral reconstruction is reported to be up to 90% (10). Table 37.3 summarizes results of urethral reconstruction (14).

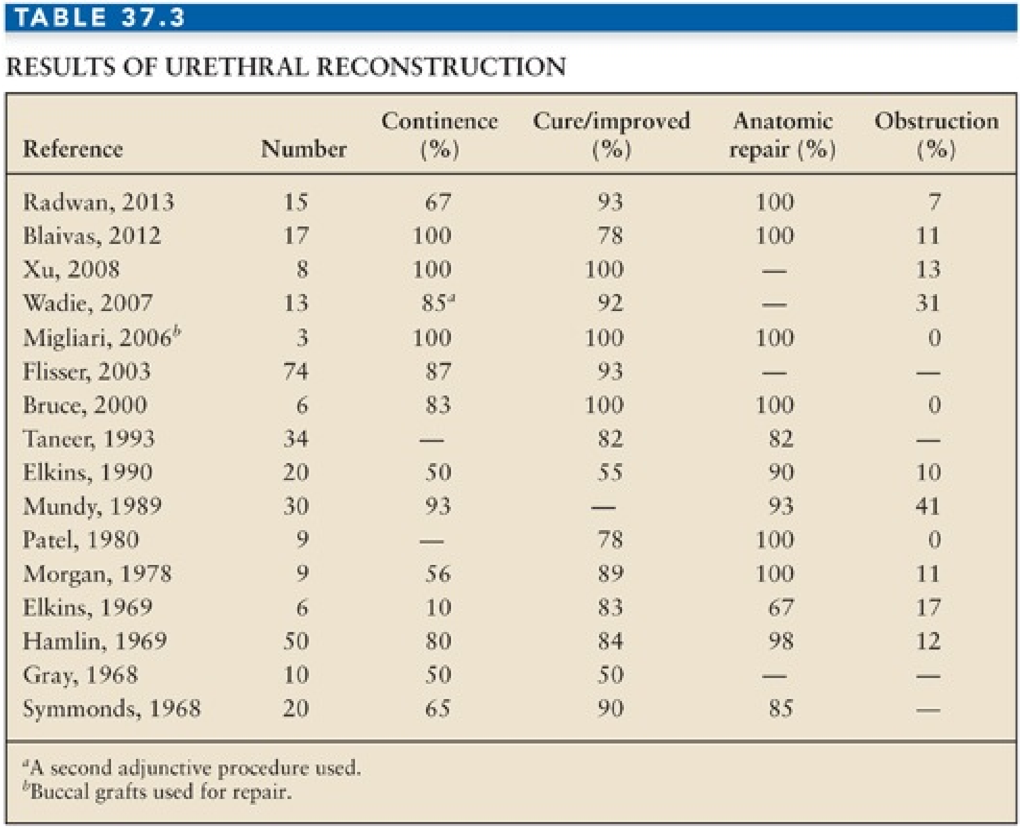

TABLE 37.3

RESULTS OF URETHRAL RECONSTRUCTION

Reference	Number	Continence (%)	Cure/improved (%)	Anatomic repair (%)	Obstruction (%)
Radwan, 2013	15	67	93	100	7
Blaivas, 2012	17	100	78	100	11
Xu, 2008	8	100	100	—	13
Wadie, 2007	13	85[a]	92	—	31
Migliari, 2006[b]	3	100	100	100	0
Flisser, 2003	74	87	93	—	—
Bruce, 2000	6	83	100	100	0
Taneer, 1993	34	—	82	82	—
Elkins, 1990	20	50	55	90	10
Mundy, 1989	30	93	—	93	41
Patel, 1980	9	—	78	100	0
Morgan, 1978	9	56	89	100	11
Elkins, 1969	6	10	83	67	17
Hamlin, 1969	50	80	84	98	12
Gray, 1968	10	50	50	—	—
Symmonds, 1968	20	65	90	85	—

[a] A second adjunctive procedure used.
[b] Buccal grafts used for repair.

Complications

Postoperative complications can be minimized by careful adherence to the general principles of reconstruction; however, in complex reconstructive cases, such problems are not rare.

Complications may include bleeding which can be avoided by careful and meticulous dissection in the proper surgical planes. Cautery to control bleeding should be used with caution as this may jeopardize blood supply and lead to flap necrosis.

Urethrovaginal fistula may result and may require additional procedures. Meticulous attention to surgical technique, good hemostasis, avoidance of infection, preservation of a well-vascularized anterior vaginal wall flap, and a multilayered closure with avoidance of overlapping suture lines should minimize the risk of urethrovaginal fistula formation.

Urinary obstruction may develop secondary to scarring or from the pubovaginal sling. Such an occurrence may require additional procedures such as urethral dilation, urethral reconstruction, or sling incision with or without urethrolysis.

Urinary incontinence from sphincteric deficiency may develop in 50% to 90% of patients not undergoing concomitant sling. Blavias and Heritz (13) reported successful reoperation in such patients who suffered from sphincteric incontinence. Recurrent stricture was reported by Blavias et al. (14) in 2 of 17 patients (11%) who underwent urethral reconstruction for female urethral stricture. Meatal stenosis has also been reported (15).

RECONSTRUCTION OF THE FEMALE URETHRA FOR URETHRAL DIVERTICULUM

Urethral diverticula (UD) in women represent a challenge in both diagnosis and reconstruction for the surgeon. The actual prevalence of UD is not known, but it is reported to occur in 1% to 6% of adult women (16,17). UD is an epithelialized cavity dissecting its way within the fascia of the urethropelvic ligament (Fig. 37.8) (18). This cavity forms an isolated cyst-like appendage, usually with a single connection to the urethral lumen, termed the *neck* or *ostium*. Complicated UD may extend partially around the urethra to form a “saddlebag” UD, or more uncommonly anterior to the urethra (19), or circumferentially around the urethra (20).

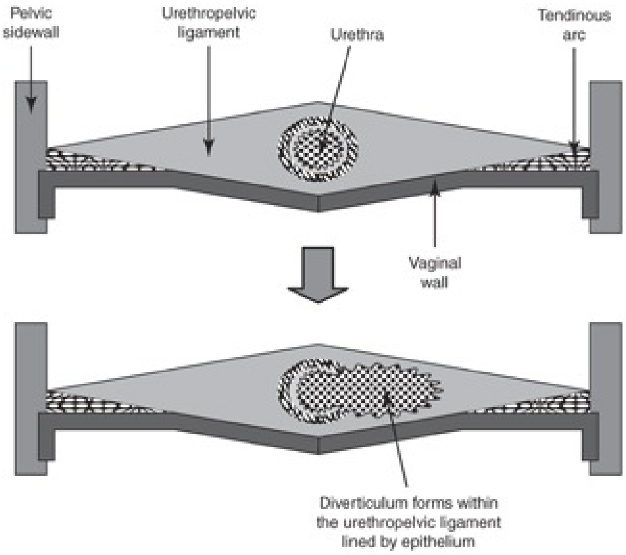
Pelvic sidewall
Urethropelvic ligament
Urethra
Tendinous arc
Vaginal wall
Diverticulum forms within the urethropelvic ligament lined by epithelium

FIGURE 37.8 Diverticulum forms within the urethropelvic ligament.

It is generally believed that an adult UD is formed secondary to infection and obstruction of the periurethral glands. These glands are tubuloalveolar glands and are anatomically located in the distal one-third of the urethra ventral and lateral to the urethral lumen. It is postulated that infection of these glands leads to abscess formation and eventual rupture of the abscess back into the urethral lumen, resulting in an epithelialized cavity in communication with the urethra.

Often, although not invariably highly symptomatic due to the location, the most common coexisting condition is probably urinary incontinence, especially stress urinary incontinence (SUI), which may coexist in up to 50% of individuals (16). Malignant and benign tumors in UD are quite rare. The most common malignant pathology in UD is adenocarcinoma, followed by transitional cell and squamous cell carcinomas. Calculi within UD may be diagnosed in 4% to 10% of cases and are most likely due to urinary stasis and/or infection.

Diagnosis

The diagnosis of UD can be made with a combination of a thorough history, physical examination, and selected imaging. The symptoms of UD are classically described as the “three Ds”: dysuria, dyspareunia, and dribbling (postvoid). However, common presenting symptoms vary and include storage and voiding symptoms, pain, and urinary tract infection (UTI), which is reported in almost one-third of patients (21). Other symptoms include a vaginal mass, hematuria, vaginal discharge, obstructive voiding symptoms, and even urinary retention. Up to 20% of patients may be completely asymptomatic and are thus diagnosed incidentally on imaging or physical examination. Symptomatic patients may often be overlooked and treated for years for a number of unrelated conditions, such as interstitial cystitis, recurrent cystitis, vulvodynia, endometriosis, and vulvovestibulitis, before the diagnosis of UD is made.

Physical examination should include a careful inspection of the anterior vaginal wall. Masses or areas of tenderness should be noted and further examined. Suspected UD should be carefully differentiated from vaginal prolapse, including cystourethrocele, vaginal wall cyst, or Skene gland abscess. Most UDs are located ventrally over the middle and proximal portions of the urethra corresponding to the area of the anterior vaginal wall 1 to 3 cm inside the introitus. During physical examination, a tender cystic mass is felt on the anterior vaginal wall and may be gently “stripped” or “milked” distally in an attempt to express purulent material or urine from within the urethral lumen out through the urethral meatus, which strongly suggests the diagnosis of UD.

Endoscopic examination of the bladder and urethra is performed in an attempt to visualize the UD ostium (communication to the urethra) as well as to evaluate for other causes of the patient’s presenting symptoms. A flexible cystoscope or a specially designed rigid female cystoscope with a short beak to maintain the discharge of the irrigation solution immediately adjacent to the lens is most useful in visualizing the lumen of the relatively short female urethra. During cystoscopy, simultaneous gentle compression of the bladder neck and the diverticular sac with an assistant’s finger can express luminal discharge of purulent material during urethroscopy localizing the ostium.

High-quality preoperative imaging is important in the diagnosis of UD as well as in planning operative therapy. This will help to provide an accurate reflection of the relevant anatomy of the UD and its anatomic relationships. No single study can be considered the gold standard for the evaluation of UD. Furthermore, the availability and quality of individual radiologic techniques is quite variable across centers. Currently available techniques for the evaluation of UD include double-balloon positive-pressure urethrography (PPU), VCUG, ultrasound (US), and magnetic resonance imaging (MRI) with or without an endoluminal coil (eMRI). eMRI (22) has several distinct advantages over VCUG; however, these studies are often complementary. We currently use MRI in the evaluation of all patients with known or suspected UD because the complexity of these lesions is more readily appreciated using this technique (Fig. 37.9). Urodynamic studies, especially VUDs, are used in patients with urinary incontinence or significant voiding dysfunction in order to characterize these symptoms, especially if surgery is planned. This may also help in counseling the patient about the value of a synchronous anti-incontinence procedure. These studies are also useful in evaluating the anatomy of the UD, assessing the competence of the bladder neck, assessing bladder function, and confirming the diagnosis of SUI.

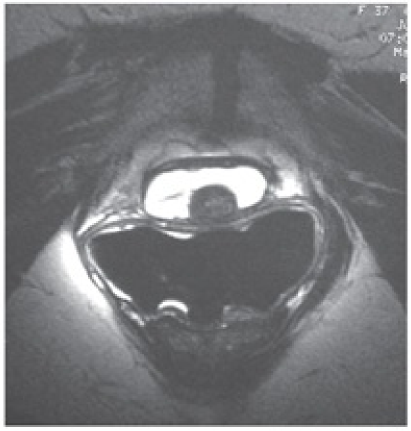

FIGURE 37.9 Axial T2-weighted MRI of an unusual anterior urethral diverticulum.

Indications for Surgery

Symptomatic patients should be offered surgical excision and reconstruction. Those with concomitant SUI can be considered for a simultaneous anti-incontinence procedure at the time of UD excision.

Asymptomatic patients and those who are unwilling or medically unable to undergo surgical excision should be informed that the natural history of untreated UD is unknown. In such cases, patients should be counseled that certain carcinomas or other complications such as stones or urinary incontinence may arise and that close follow-up is warranted.

Alternative Therapy

For patients electing nonoperative management, a conservative approach can be offered with daily low-dose antibacterial prophylaxis for infection and digital stripping of the anterior vaginal wall following micturition to prevent postvoid dribbling and reduce the risk of UTI due to stasis in the UD.

Most commonly, UD are treated with a complete excision and urethral reconstruction (16). However, a variety of other surgical interventions for UD have been reported. Approaches have included transurethral and open marsupialization, endoscopic unroofing, fulguration, incision and obliteration, and coagulation (16). One noteworthy alternative to excision and reconstruction is transvaginal marsupialization as described by Spence and Duckett (23). This approach may reduce operative time, blood loss, and recurrence rate but is probably only applicable to UD in very selected cases involving the distal one-third of the urethra due to the risk of sphincteric injury and resulting de novo SUI in those UD located more proximally. This procedure involves incision of the urethra at the floor from the level of the diverticular ostium to the urethral meatus. This will result in urinary spraying and vaginal voiding.

In rare cases, when the UD is highly symptomatic, acutely infected, and unresponsive to antibiotic therapy, or in cases when a complete elective excision should be postponed, such as during pregnancy, a transvaginal incision (diverticulotomy) can be performed directly into the UD cavity. This will create a temporary urethrovaginal fistula from the UD ostium through the UD cavity into the vagina, thus decompressing the diverticulum. The UD and fistula are subsequently repaired at the time of planned elective excision and reconstruction.

Surgical Technique

Excision and reconstruction is probably the most common surgical approach to UD in the modern era. The principles of the urethral diverticulectomy operation have been well described (Table 37.4). There are only a few minor differences between surgical approaches, including the type of vaginal incision (inverted “U” versus inverted “T”), whether it is necessary to remove the entire mucosalized portion of the UD, and finally, the optimal type of postoperative catheter drainage (urethra only versus urethra and suprapubic).

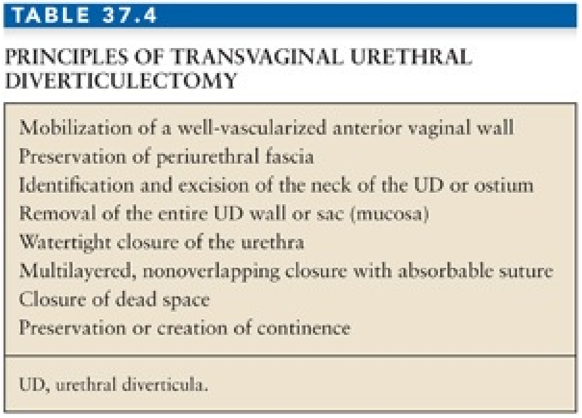

TABLE 37.4

PRINCIPLES OF TRANSVAGINAL URETHRAL DIVERTICULECTOMY

Mobilization of a well-vascularized anterior vaginal wall
Preservation of periurethral fascia
Identification and excision of the neck of the UD or ostium
Removal of the entire UD wall or sac (mucosa)
Watertight closure of the urethra
Multilayered, nonoverlapping closure with absorbable suture
Closure of dead space
Preservation or creation of continence

UD, urethral diverticula.

Preoperative preparation includes (a) antibiotic administration in patients with recurrent or persistent UTIs to control infection, (b) stripping of the anterior vaginal wall to prevent urinary stasis and recurrent UTIs, and (c) application of topical estrogen creams for several weeks prior to surgery in postmenopausal patients with atrophic vaginitis to optimize the quality of vaginal tissue and promote healing.

The patient is placed in a high lithotomy position with all pressure points well padded. We have found that the use of padded adjustable stirrups for the lower extremities greatly enhances operative access to the female perineum. A standard vaginal antiseptic preparation is applied. The use of a headlight as well as operative magnification (1.5× to 2.0×) assists with the dissection and precise reconstruction. A Foley catheter (16Fr) is placed in the urethra. A suprapubic tube may be used for an additional postoperative urinary drainage if desired. An appropriate preoperative antibiotic is given.

A weighted vaginal speculum and Scott retractor with hooks offer enhanced exposure. An inverted U is marked out along the anterior vaginal wall proximal from the urethral meatus with the limbs extending to the bladder neck or beyond (Fig. 37.10). The inverted U incision provides excellent exposure laterally at the level of the midvagina and can be extended proximally as needed for lesions that extend beyond the bladder neck. Hydrodissection with normal saline can be used along the lines of the incision beneath the vaginal wall to facilitate dissection. A posterolateral episiotomy may be of help in some patients with a narrow introitus, especially in nulliparous women.

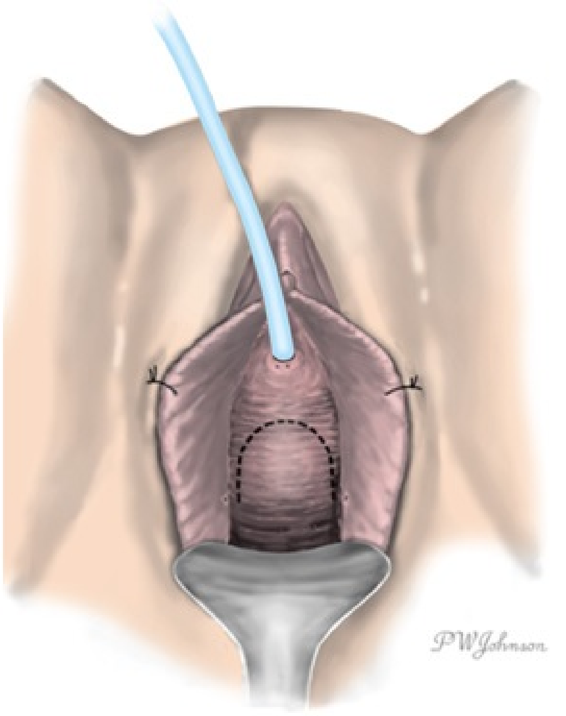

FIGURE 37.10 Incision along the anterior vaginal wall, with the base of the U at the level of the distal urethra, provides an excellent lateral exposure at the midvagina for transvaginal urethral diverticulectomy. (Reprinted with permission from Rovner ES. Urethral diverticula. In: Raz S, Rodriguez L, eds. *Female Urology*, 3rd ed. Philadelphia: Elsevier, 2008:825–844. Copyright © 2008 Elsevier Inc. All rights reserved.)

An anterior vaginal wall flap is created by careful dissection in the potential space between the vaginal wall and the periurethral fascia. The use of sufficient countertraction during this portion of the procedure is important in maintaining the proper plane of dissection and aid in the dissection process.

During the dissection, it is important to (a) preserve the periurethral fascia, (b) maintain an adequate blood supply to the anterior vaginal wall flap, and (c) avoid inadvertent and premature entry into the UD. The periurethral fascia forms a distinct layer that is usually interposed between the vaginal wall and the UD; however, in some lesions, it may be deficient (24). Preservation and later reconstruction of the periurethral fascia is of paramount importance in order to prevent UD recurrence, close dead space, and overlap the suture lines in order to avoid urethrovaginal fistula formation postoperatively. Pseudodiverticula have been described where this layer of tissue is considerably attenuated or even absent (24). In these patients, an interpositional flap, or graft such as a pubovaginal sling, may be used for reconstruction.

Following the completed takedown of the anterior vaginal wall flap, the periurethral fascia is incised sharply transversely (Fig. 37.11). Proximal and distal layers of periurethral fascia are carefully developed by both sharp and blunt dissection, avoiding entrance into the UD. The UD is then sharply dissected back to its origin on the urethra at the ostium within the leaves of the periurethral fascia (Fig. 37.12). In many cases, with extensive adhesions, it may be necessary to open and enter the UD to facilitate dissection from the surrounding tissues. The ostium or connection to the urethra is identified and the walls of the UD are completely excised. Every effort should be made to remove the entire mucosalized surface of the UD in order to prevent recurrence. All abnormal tissues in the area of the ostium should be removed if possible to ensure that no mucosal elements of the UD wall remain that could result in postoperative urine leakage and recurrence. Following complete excision of the UD, the urethral catheter is often seen through a defect in the urethra (Fig. 37.13). The urethra can be reconstructed over a Foley catheter as small as 14Fr without long-term risk of urethral stricture and should be closed in a watertight fashion with 4-0 synthetic absorbable sutures (Fig. 37.14). The closure should be tension-free and should include the full thickness of the urethral wall. In patients with circumferential UD, Rovner and Wein (20) described transecting the urethra and then reanastomosis to be able to access the anterior portion of the UD to ensure adequate removal of the diverticular sac. After urethral closure, the periurethral fascial flaps are reapproximated with 3-0 synthetic absorbable sutures in a perpendicular orientation to the urethral closure line in order to minimize overlap and hence the risk of postoperative urethrovaginal fistula formation (Fig. 37.15). Care is taken to secure the periurethral fascial flaps in such a way as to close all dead space.

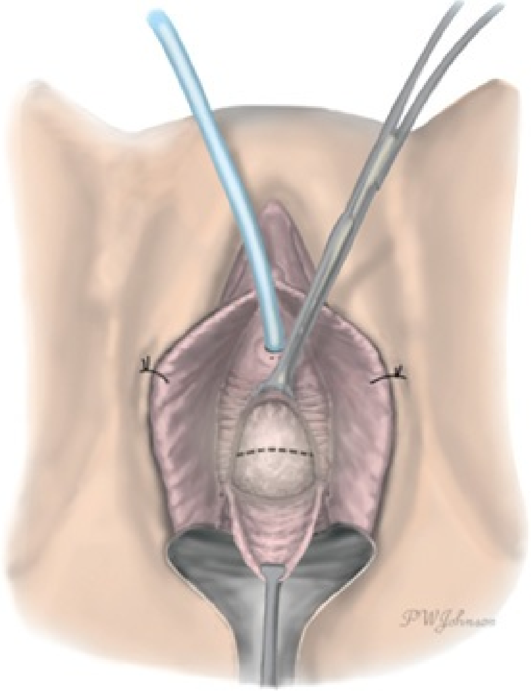

FIGURE 37.11 A transverse incision is made into the periurethral fascia. Proximal and distal layers will be carefully developed without entering the UD. (Reprinted with permission from Rovner ES. Urethral diverticula. In: Raz S, Rodriguez L, eds. *Female Urology*, 3rd ed. Philadelphia: Elsevier, 2008:825–844. Copyright © 2008 Elsevier Inc. All rights reserved.)

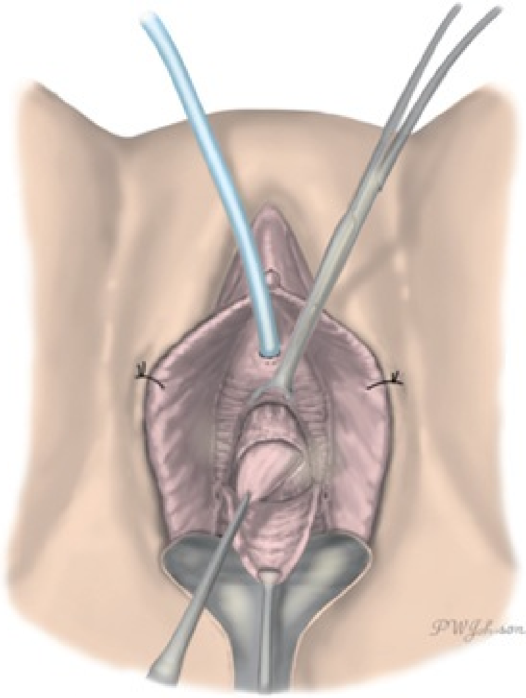

FIGURE 37.12 Following mobilization of the anterior and posterior leaves of the periurethral fascia, the urethral diverticulum is dissected back to its origin on the urethra within the leaves of the periurethral fascia. (Reprinted with permission from Rovner ES. Urethral diverticula. In: Raz S, Rodriguez L, eds. *Female Urology*, 3rd ed. Philadelphia: Elsevier, 2008:825–844. Copyright © 2008 Elsevier Inc. All rights reserved.)

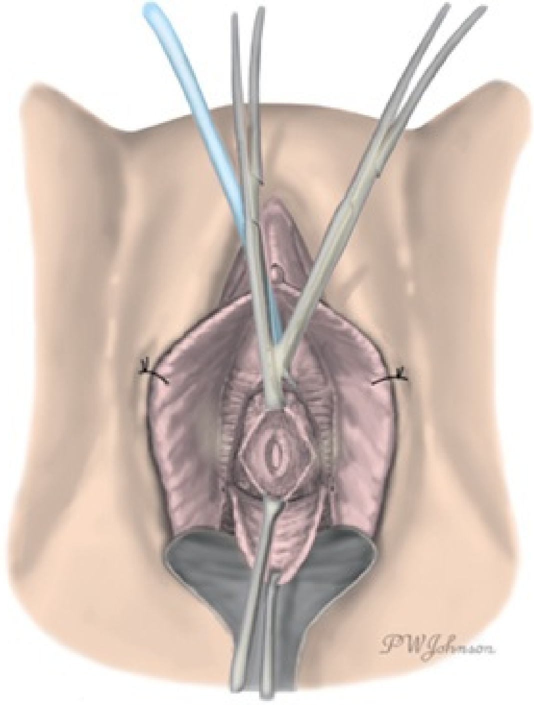

FIGURE 37.13 Following removal of the entire urethral diverticulum, the Foley catheter is often seen. (Reprinted with permission from Rovner ES. Urethral diverticula. In: Raz S, Rodriguez L, eds. *Female Urology*, 3rd ed. Philadelphia: Elsevier, 2008:825–844. Copyright © 2008 Elsevier Inc. All rights reserved.)

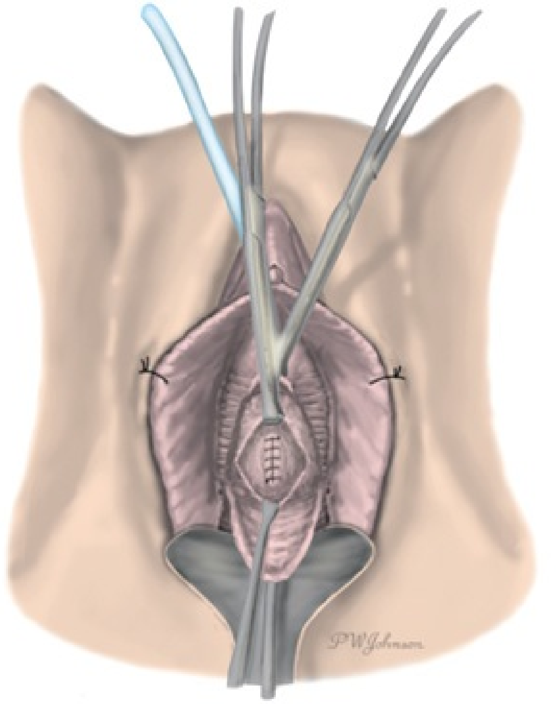

FIGURE 37.14 Closure of the urethra with absorbable suture should be watertight and tension-free. (Reprinted with permission from Rovner ES. Urethral diverticula. In: Raz S, Rodriguez L, eds. *Female Urology*, 3rd ed. Philadelphia: Elsevier, 2008:825–844. Copyright © 2008 Elsevier Inc. All rights reserved.)

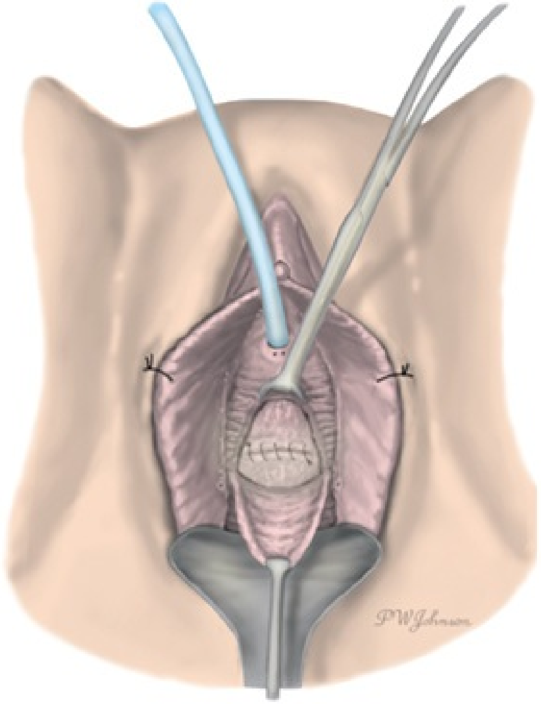

FIGURE 37.15 Closure of the periurethral fascia should be perpendicular to the urethral closure line to minimize overlap and the risk of urethrovaginal fistula. (Reprinted with permission from Rovner ES. Urethral diverticula. In: Raz S, Rodriguez L, eds. *Female Urology*, 3rd ed. Philadelphia: Elsevier, 2008:825–844. Copyright © 2008 Elsevier Inc. All rights reserved.)

If desired, a fibrofatty labial (Martius) flap can be harvested at this point and placed over the periurethral fascia as an additional layer of closure. Indications for such a flap are not universally agreed on. However, it can be considered in (a) patients with poor-quality tissues or attenuated periurethral fascia or (b) in patients whom significant inflammation is encountered intraoperatively. A well-vascularized adjuvant flap such as a Martius flap may potentially reduce the risk of wound breakdown and subsequent complications such as urethrovaginal fistula.

The anterior vaginal wall flap is then repositioned and reapproximated with absorbable 2-0 sutures (Fig. 37.16). This completes a three-layer closure (four layers if a Martius flap is used). An antibiotic impregnated vaginal pack is placed postoperatively.

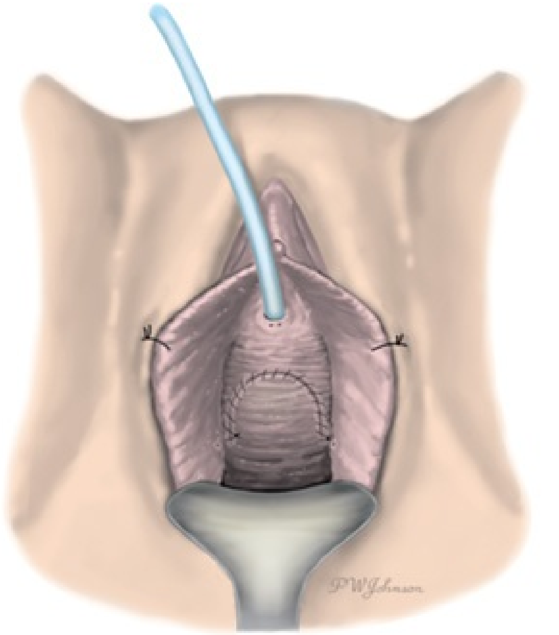

FIGURE 37.16 Closure of the vaginal wall with reapproximation of the anterior vaginal wall flap. This completes a three-layer closure including closure of the urethra, periurethral fascia, and vaginal wall. (Reprinted with permission from Rovner ES. Urethral diverticula. In: Raz S, Rodriguez L, eds. *Female Urology*, 3rd ed. Philadelphia: Elsevier, 2008:825–844. Copyright © 2008 Elsevier Inc. All rights reserved.)

The vaginal packing is removed within 6 to 24 hours, and the patient is discharged home with closed urinary drainage. Antispasmodics are used liberally to reduce bladder spasms. A pericatheter VCUG is obtained at 14 to 21 days postoperatively. If there is no extravasation, the catheters are removed. If extravasation is seen, then repeat pericatheter VCUGs are performed weekly until resolution is noted. In the vast majority of cases, extravasation will resolve in several weeks with this type of conservative management.

Complications

Postoperative complications can be avoided by careful adherence to the principles of transvaginal urethral diverticulectomy. Nevertheless, complications may arise. Large diverticula (>4 cm) or those associated with a lateral or horseshoe configuration may be associated with a greater likelihood of postoperative complications (25). Complications include recurrent diverticulum (1% to 29%), stress incontinence (1.7% to 16.0%), urethral stricture (0% to 5%), and recurrent UTIs (0% to 31%) (16).

Intraoperative bleeding can be avoided by maintaining the proper plane of dissection during takedown of the anterior vaginal wall flap. If bleeding is encountered, cautery or suture ligature can be used. Excessive use of cautery should be avoided because this can lead to flap necrosis and fistula formation.

Urethrovaginal fistula is a disabling but fortunately rare complication that may result from diverticulectomy. A fistula can be located either distal or proximal to the sphincteric mechanism. A distally located fistula is usually not associated with symptoms other than perhaps a split urinary stream and/or vaginal voiding. As such a distal urethrovaginal fistula may not require repair, although some patients may request repair. Conversely, a proximal fistula located at the bladder neck or within the proximal half of the urethra in patients with an incompetent bladder neck will likely result in considerable symptomatic urinary leakage. These patients should undergo repair with or without the use of an adjuvant tissue flap such as a Martius flap to provide a well-vascularized additional tissue layer. Meticulous attention to surgical technique, good hemostasis, avoidance of infection, preservation of the periurethral fascia, a well-vascularized anterior vaginal wall flap and a multilayered closure with nonoverlapping suture lines should minimize the potential for postoperative urethrovaginal fistula formation.

Coexisting SUI can be treated at the time of urethral diverticulectomy as noted previously. Synthetic materials should not be used in this setting (11). However, de novo SUI may occur following urethral diverticulectomy. The proximity of most UDs to the sphincter mechanism puts the patient at risk for this complication even with meticulous attention to surgical technique.

Persistence or recurrence of symptoms following diverticulectomy may occur in some patients. This may be caused by a new medical problem (e.g., UTI), a new UD, or alternatively, recurrence of the original lesion. Recurrence of a UD may be due to incomplete excision of the UD, inadequate closure of the urethra or residual dead space, or other technical factors. Ljungqvist et al. (26) found recurrence in 11 out of 68 of their patients over 26-year follow-up with a 92% overall satisfaction. Repeat urethral diverticulectomy surgery can be challenging due to altered anatomy, scarring, and the difficulty of identifying the proper anatomic planes.

Outcomes

The significance of appropriate preoperative patient counseling regarding surgery and postoperative expectations of cure cannot be overemphasized. Individuals with UD have a myriad of symptoms, including pain, UTIs, and urinary dysfunction. Although these are often related to the presence of the UD, sometimes they do not resolve even with a technically successful surgery. Nevertheless, surgical outcome for the UD has generally been good. Outcome can be evaluated by resolution of the patient's symptoms or recurrence of the diverticulum. Successful excision of UD has been reported in 85% of patients (21).

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CHAPTER 38 ■ SURGICAL MANAGEMENT OF THE INCOMPETENT BLADDER OUTLET IN THE PATIENT WITH A NEUROGENIC BLADDER

TERESA L. DANFORTH AND DAVID A. GINSBERG

The two primary goals of treatment of patients with neurogenic bladder (NGB) include protection of the upper urinary tracts by maintaining low storage pressures and allowing the patient to sustain optimal urinary control. Incontinence may be due to bladder dysfunction (i.e., detrusor overactivity) and/or bladder outlet dysfunction. The bladder outlet in patients with NGB may behave in one of three ways: normal functioning outlet, obstructed outlet (often caused by detrusor external sphincter dyssynergia [DESD] leading to incomplete bladder emptying or urinary retention), or an incompetent bladder outlet leading to incontinence.

DESD is usually seen in patients with suprasacral spinal cord injury and is defined as involuntary contraction of the striated sphincter at the time of a detrusor contraction. This may result in obstruction from the contracted external sphincter as well as activation of the sacral arc reflex leading to a poorly sustained bladder contraction and incomplete bladder emptying. If male patients are unable or unwilling to perform intermittent catheterization (IC), standard treatment is usually reflex voiding to an external catheter which is often combined with either pharmacologic (alpha-blocker, baclofen, onabotulinumtoxinA) or surgical external sphincterotomy to maintain satisfactory bladder emptying. Patients with DESD and recurrent autonomic dysreflexia are also considered candidates for sphincterotomy to ameliorate their symptoms. Repeat sphincterotomy is commonly necessary in this population, and growth of the prostate may require subsequent bladder neck incision or resection to relieve obstruction at the bladder neck. Patients who can no longer use condom catheters secondary to body habitus may require management with an indwelling catheter.

The incompetent bladder outlet has multiple etiologies, all resulting in incontinence at baseline. Patients with sacral spinal cord injury, spina bifida, or history of radical pelvic surgery may have an incompetent bladder outlet secondary to dysfunction of the striated and/or smooth sphincters. Iatrogenic destruction of the outlet may be caused by prior transurethral resection of the prostate or chronic indwelling catheter (Fig. 38.1).

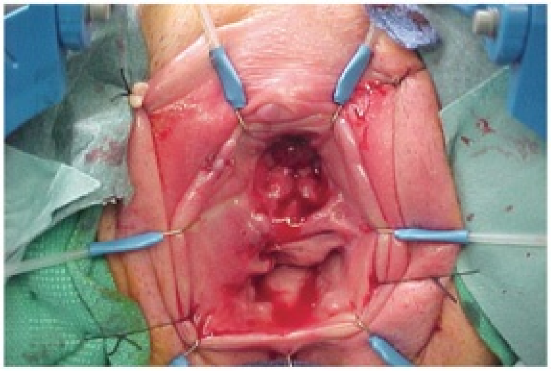

FIGURE 38.1 Urethral erosion. A patulous urethra caused by a chronic indwelling catheter in a female with multiple sclerosis.

Female patients with NGB present unique challenges because women have more difficulty with IC due to inaccessible anatomy. Sphincterotomy is not an option for females with DESD because there is not an adequate external collection device currently available. Females may also have baseline stress urinary incontinence of nonneurogenic etiology in addition to their NGB voiding dysfunction. Incontinence may be exacerbated by detrusor overactivity as commonly seen in patients with multiple sclerosis.

This chapter will discuss the surgical options for treatment of the patient with NGB and an incompetent bladder neck, focusing on technique of bladder neck closure (BNC).

SURGICAL OPTIONS

Management of the incompetent bladder neck varies depending on the degree of incontinence and the health of the existing urethra. Options include injectables, transvaginal slings, puboprostatic slings, artificial urinary sphincter (AUS), and BNC, transvaginal or abdominal, with or without bladder reconstruction.

Patients with mild incontinence may benefit from injectable therapy (1–3). The few studies in the neurogenic patient population report that often multiple injections are needed with an improvement rate of up to 67% but low cure rates. None of these studies evaluate long-term efficacy. Theoretically, this would not be an optimal therapy for a patient population requiring regular IC. Long-term results in nonneurogenic patients show relatively poor durability.

Slings have been used in the management of incontinence for both neurogenic and nonneurogenic patients. Female patients with adequate urethral length may be candidates for either a mesh midurethral sling or an autologous fascial sling at the bladder neck. Male patients may benefit from a mesh sling placed in the perineum or a puboprostatic fascial sling. Little data is available on the use of male slings in patients with NGB. Groen et al. (4) recently evaluated 20 male patients who underwent the AdVance male sling and found a 65% improvement and/or cure rate. The advantage to using mesh slings in both sexes includes shorter operative time and less morbidity. However, if the sling's purpose is to obstruct the outlet in patients who catheterize, many prefer to use fascia because it allows the surgeon to put more tension on the urethra without the risk of mesh erosion (5).

AUSs are commonly used in male patients with NGB (less commonly in females), both in those who reflex void as well as those who do IC. Patients must have adequate hand function to use the pump located in the scrotum. AUS revision rates at 5 years are approximately 20% to 25% due to mechanical failure, infection, and urethral erosion (6). Most studies regarding AUS procedures in NGB patients have been in children, with higher revision rates, upward of 36%, likely secondary to the younger ages at which the prosthesis is placed as well as increased complexity of the case (7). Herndon et al. (8) report cuff erosion rates of 16% in the NGB population, not surprisingly higher than nonneurogenic patients because many NGB patients perform regular IC.

BNC is a relatively uncommon procedure, usually reserved as a last resort. In the female patient, BNC may be performed transvaginally or abdominally.

INDICATIONS FOR BLADDER NECK CLOSURE

Females

Female patients with NGB and incontinence managed with an indwelling urethral catheter frequently suffer from leakage around the catheter, leading to upsizing of the catheter and increases in balloon volume, eventually causing a patulous urethra. Patients with sufficient urethral length may benefit from a fascial sling. Watanabe et al. (9) report that for adequate urethral compression, a patient must have an intact bladder neck and 1 cm of proximal urethral tissue. Unfortunately, this is not usually the case in many females with this issue who may have erosion up to the level of the pubic symphysis. The erosion seen in these patients may be severe enough that the bony undersurface of the pubic symphysis can be directly palpated per the urethra and one or even two fingers can be placed directly into the bladder. Other indications may include failed urethrovaginal fistula repair or severe intrinsic sphincter deficiency that has not responded adequately to prior treatments.

As opposed to the abdominal approach, transvaginal BNC is preferred in patients who have not undergone prior pelvic radiation and will be managed long term with a suprapubic tube (SPT). Prior pelvic radiation may significantly devascularize the vaginal tissue and increase risk of fistulas. If one is planning concomitant lower urinary tract reconstruction, for example, in order to create a continent catheterizable stoma, the abdominal approach is preferred.

Males

Male patients who have failed prior treatments for incontinence or those who develop urethrocutaneous fistulas are candidates for BNC. The typical scenario that leads to BNC in men is the male patient with severe pressure ulcer disease which has involved the urethra, resulting in a large urethral defect within the pressure ulcer that is unable to be repaired. Patients who are not candidates for AUS secondary to hand function or those with severe urethral stricture disease not amenable to repair are also good candidates. BNC concomitantly with salvage prostatectomy and bladder reconstruction after radiation for prostate cancer or for complications secondary to cryotherapy has been described (10,11).

PREOPERATIVE WORKUP

The preoperative evaluation and patient selection are of vital importance to the success of BNC. History of prior pelvic, urethral, and flap surgeries and history of radiation to the pelvis should be elicited. Assessment of the patient's medical comorbidities will help determine how extensive a procedure to pursue. Physical exam should assess a patient's ability to be positioned appropriately in the operating room, as patients with severe contractures may make vaginal access impossible. One should also assess the skin integrity of the perineum.

If the patient has limited hand function, it is important to assess the ability to catheterize if the patient desires a continent cutaneous diversion. If unsure, referral to occupational therapy will help determine if the patient will be able to perform IC. If a patient does not want to IC, decision of an incontinent stoma (conduit versus BNC and ileovesicostomy) versus SPT will often be determined by the patient's comorbidities and preference regarding bladder management.

Patients with chronic indwelling catheters or who are wheelchair-bound are often debilitated and malnourished. It is important to assess preoperative nutrition status because poor nutritional status is associated with poor wound healing, increased rate of infection, higher pulmonary complication rates, prolonged hospitalization, and higher mortality (12).

The bladder should be evaluated with cystoscopy, especially in patients with chronic indwelling catheters, to rule out any malignancy. If considering a continent diversion, it is important to evaluate bladder filling pressures with urodynamics. This often requires placement of a catheter balloon at the bladder neck to prevent leakage at the incompetent outlet, thus allowing the bladder to fill. Fluoroscopy will allow for assessment for any bladder diverticula or vesicoureteral reflux. Patients with elevated storage pressures may require an augmentation cystoplasty along with construction of the continent urinary stoma.

In patients with urethrocutaneous fistulas, it is often helpful to evaluate the urethra with a retrograde urethrogram with or without voiding cystourethrogram to document the extent and location of the fistula.

It is imperative to counsel the patient and the caregiver preoperatively about the options and risks of surgery. A transvaginal approach is certainly less morbid; however, it is associated with higher postoperative fistula rates than the abdominal approach (13–18). The potential need for subsequent procedures must be discussed to set appropriate expectations. Surgeon experience also must be taken into account because inexperienced pelvic surgeons might find the transvaginal approach technically challenging.

SURGICAL TECHNIQUE

BNC can be performed vaginally in women or transabdominally in both sexes. Regardless of technique, BNC requires adequate mobilization of the bladder neck, multilayer, tension-free closure with nonoverlapping suture lines and consideration of interposition of tissue over the closed bladder. The bladder can be reconstructed to allow for IC or continuous drainage via a stoma or drainage by an SPT. Specifics of lower urinary tract reconstruction will be addressed in other chapters. All patients should have preoperative urine culture to plan appropriate antibiotic coverage to sterilize urine.

Vaginal Approach

The vaginal approach is reserved for women who desire permanent bladder drainage via SPT, thus decreasing morbidity by avoiding an abdominal incision. As discussed previously, the vaginal approach might be difficult for surgeons who lack experience with pelvic surgery. Patients are placed in high dorsal lithotomy position with Trendelenburg, and care taken to pad pressure points to avoid nerve injury. Notably, patients who have been bedbound or are contracted may be difficult to position in lithotomy position, making the vaginal approach more challenging. The patient is prepped vaginally as well as up to the level of the umbilicus for SPT placement. A Lone Star self-retaining retractor is placed as well as a posteriorly weighted vaginal speculum to allow for maximum vaginal exposure. A headlight may be used to allow for better visualization, but it is not always necessary.

If an SPT is not already present, one should be placed before the BNC is performed. The anterior vaginal wall is infiltrated with injectable saline or 60 U per 100 mL solution of vasopressin to aid in the dissection of the vaginal wall from the urethra and bladder. A waterproof marking pen may be used to mark two intended incisions along the anterior vaginal wall: one circumferentially around the urethral meatus and the second as an inverted wide-based anterior vaginal wall flap, beginning from the urethral meatus extending past the bladder neck (Fig. 38.2). The vaginal wall flap allows for better access to the bladder neck dissection, and it will later be advanced over the closed bladder neck. The urethra is sharply dissected laterally over the periurethral fascia to the retropubic space and off of the urethropelvic ligaments, followed by transection of the urethra off of the urethropelvic ligament dorsally to the inferior margin of the pubic symphysis (Fig. 38.3). This allows for complete mobilization of the remaining urethra and bladder neck. The ureteral orifices should be identified so as to avoid injury. One ampule of indigo carmine can be given intravenously to help identify their location. The necrotic urethral tissue is then removed, which may in fact be the entire urethra, thus making bladder neck mobility extremely important. If there is viable urethral tissue, the anterior urethra is divided toward the bladder neck and closed by reapproximating the posterior urethra to the anterior urethra, closing the urethra with two layers of absorbable running suture (Fig. 38.4). The urethra is then rotated in an anterior and cephalad direction and secured to the anterior bladder wall with two layers of absorbable suture (Fig. 38.5). This rotates the suture line anteriorly, toward the retropubic space and underneath the pubic symphysis, minimizing overlying suture lines during closure of the vaginal wall flap. In addition, if possible, the sutures used to close the bladder neck can be secured to the undersurface of the pubic symphysis, further placing the BNC anteriorly, away from the vaginal incision. Mobilization of the closure upward should minimize the risk of postoperative fistula formation.

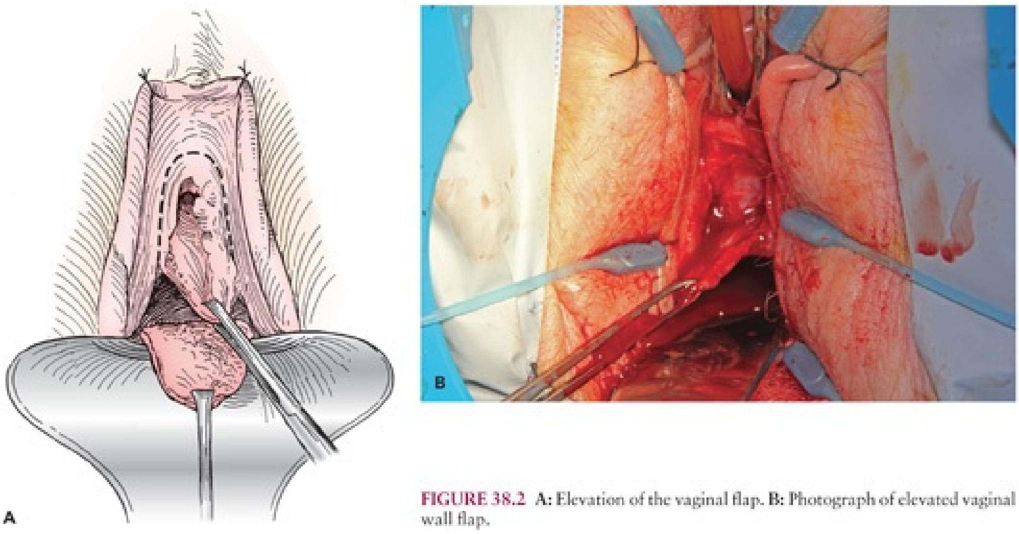

FIGURE 38.2 A: Elevation of the vaginal flap. B: Photograph of elevated vaginal wall flap.

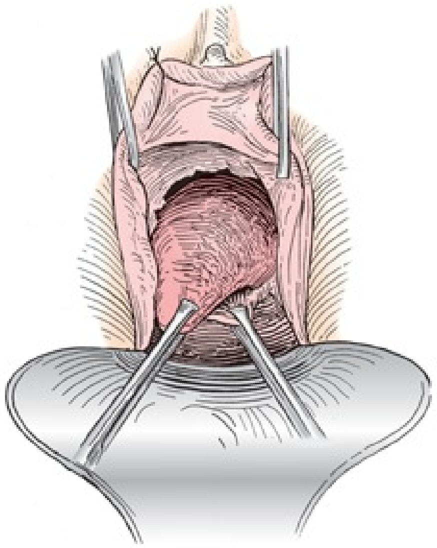

FIGURE 38.3 Mobilization of the anterior bladder neck with detachment from pubic symphysis.

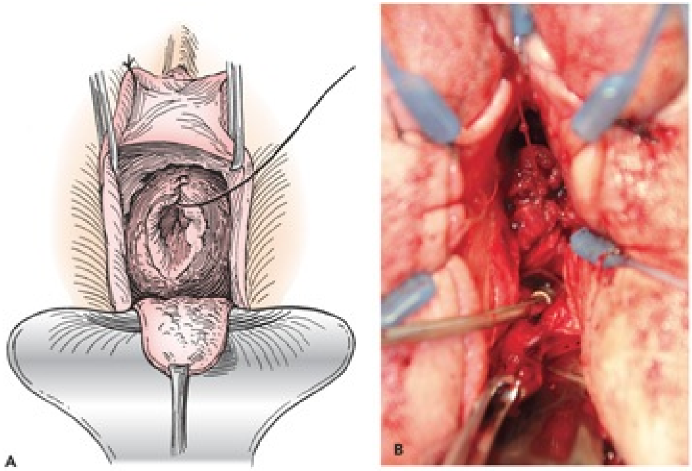

FIGURE 38.4 A: Urethral closure. B: Photograph of closed urethra.

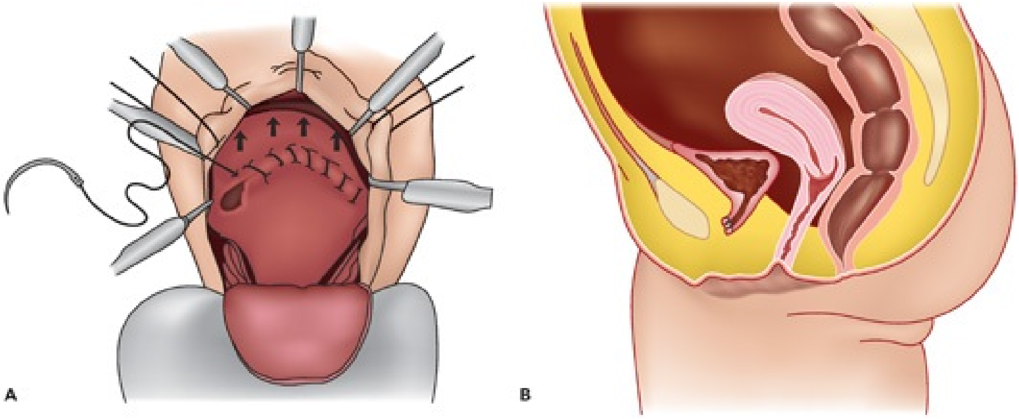

FIGURE 38.5 Rotation of bladder neck anteriorly and cephalad. A: vaginal view B: sagittal view

Flaps or graft placements are generally not necessary in primary repair. In cases where the perivesical tissues may be compromised or in patients with history of prior pelvic radiation, one can consider using a Martius flap for interposition. The fat pad from the labia majora is vascularized by either a branch of the external or internal pudendal artery and tunneled through the vaginal wall and placed over the closed bladder neck (Fig. 38.6).

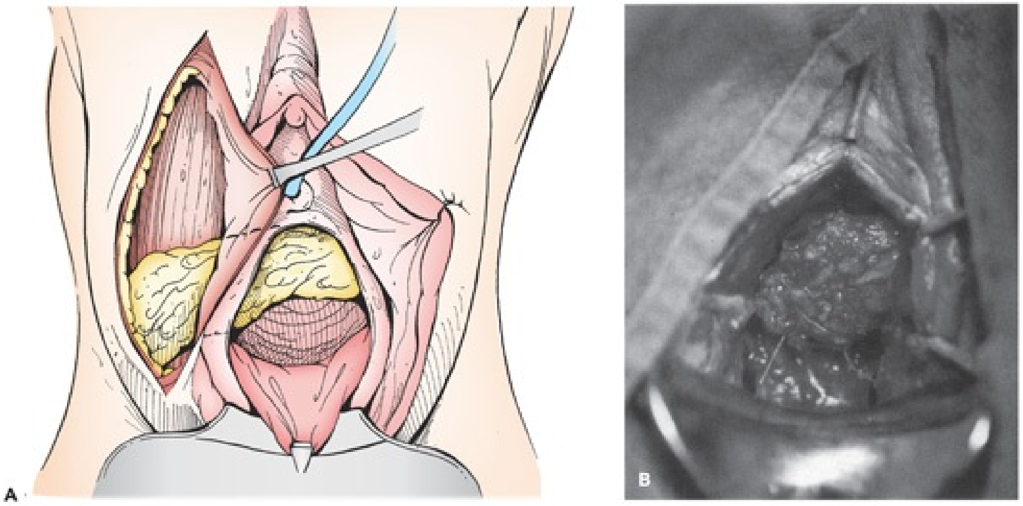

FIGURE 38.6 A: Martius flap tunneled beneath the labia minora. B: Photograph of Martius flap to close over the bladder neck.

The closure is then tested by placing dry sponges in the vagina and filling the bladder with saline colored by indigo carmine to identify any leak. Once confirmed watertight, the vaginal wall flap is closed with absorbable suture and packing is placed (Fig. 38.7). The vagina is packed overnight with antibiotic-soaked gauze.

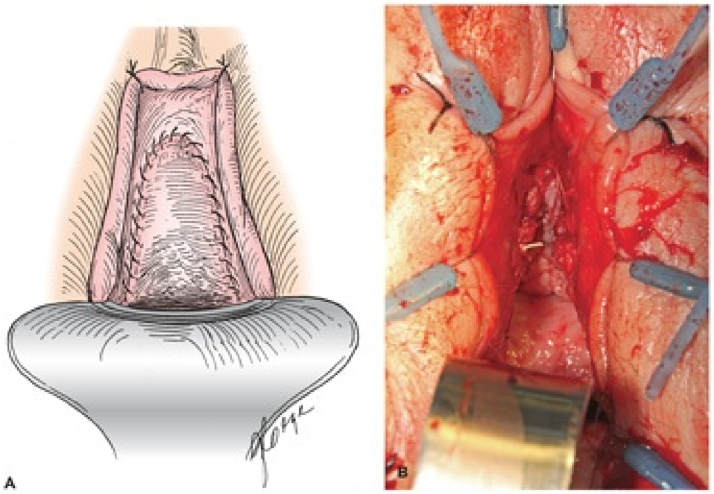

FIGURE 38.7 A: Closure of the vaginal wall flap. B: Photograph of completed vaginal wall closure.

Abdominal Approach (Women)

The abdominal approach in women is considered for patients with a history of prior failed repair, history of pelvic radiation, concomitant bladder reconstruction, or surgeon preference.

The patient is placed in low lithotomy position to allow access to the vagina throughout surgery. For those patients with significant lower extremity contractures, lithotomy position might not be possible. The patient’s entire abdomen is prepped as well as the vagina (if accessible) and an indwelling urethral catheter is placed.

A midline infraumbilical incision is used which may be extended if necessary for access to the peritoneum for bladder reconstruction or harvesting of omentum. A Pfannenstiel incision may be used in patients who plan to manage their bladder with an SPT postoperatively. The rectus muscles are retracted laterally and the space of Retzius is developed using blunt dissection. The peritoneum is retracted superiorly and a self-retaining retractor (either Balfour or Bookwalter) is placed for optimal exposure.

The bladder neck is then identified using the Foley balloon. A figure-of-eight suture is placed at the proximal urethra to ligate the dorsal venous complex. The anterior bladder neck is opened with electrocautery, and the Foley balloon is delivered into the field and secured. Allis clamps or traction sutures are used to secure the bladder neck, with care taken to avoid tearing of the tissue. Once the bladder is opened, the ureteral orifices should be identified and ureteral catheters may be placed (Fig. 38.8). If they are difficult to identify, indigo carmine may be used. The posterior bladder neck is then dissected off of the anterior vagina wall using sharp dissection and electrocautery. The entire bladder neck should be freed to allow for anterior displacement away from the vagina. The unhealthy tissue at the bladder neck is trimmed away and the ureteral catheters are removed. If the patient desires bladder reconstruction, the peritoneum is accessed to harvest bowel. If an SPT is desired, an appropriately sized catheter is brought through the anterior abdominal wall fascia and rectus muscle. The catheter is placed in the dome of the bladder and secured with a purse-string chromic suture. The bladder neck is then closed in two layers with absorbable suture. A watertight BNC is confirmed with irrigation through the SPT.

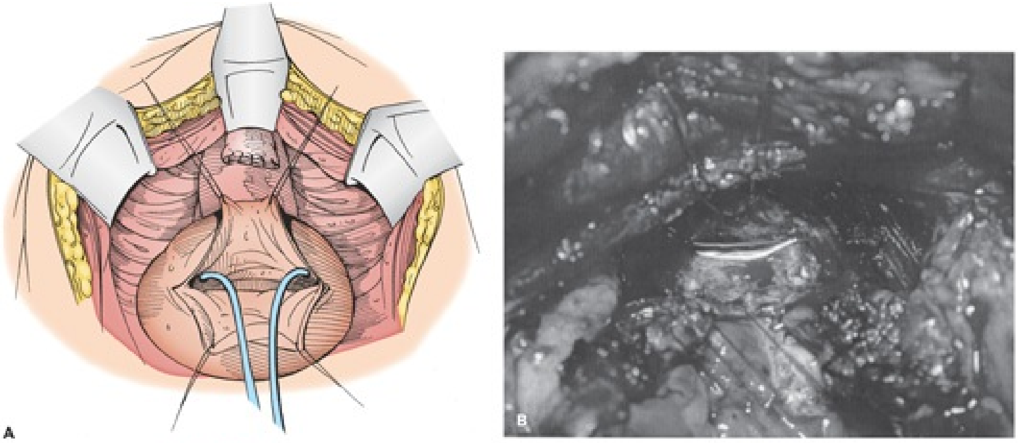

FIGURE 38.8 A: Opened bladder with mobilization of the bladder neck. B: Photograph of divided urethral stump and mobilized open bladder neck.

Peritoneum, omentum, or rectus muscle may be used as an interposition graft to decrease risk of fistula. The omentum can then be brought down and secured in the pelvis between vagina and the closed bladder neck with absorbable suture and peritoneum closed. If the omentum cannot reach the pelvis, it can be mobilized on its pedicle supplied by the left gastroepiploic artery. If omentum is not sufficient, a rectus muscle flap can be harvested with the inferior epigastric vessels as its pedicle. Once collaterals are tied, the flap is rotated downward and secured over the urethral stump. Peritoneum may be used but is not ideal due to its lack of blood supply.

Perineal Approach (Men)

BNC in men is more challenging for multiple reasons, including lack of access to the bladder neck via the perineum due to prostate anatomy and lack of potential interpositional tissue. In the perineal approach, interposition grafts for men would require a gracilis or gluteal flap, carrying higher morbidity and likely expertise of a plastic surgeon. Perineal access to the bladder neck would require a concomitant perineal prostatectomy, which has its own morbidity. Closure of the urethra distal to the prostate is technically easier; however, it has many drawbacks including high rates of fistula formation due to dependent location of closure and prostatic secretions. Distal urethral closure also compromises fertility by causing retrograde ejaculation.

Abdominal Closure (Men)

The biggest advantage to the abdominal approach in men is access to multiple sources for interposition grafts including peritoneum, omentum, and rectus muscle. The most common approach is supraprostatic closure because it is technically easier, preserves ejaculatory function, and allows for better bladder neck mobilization than an infraprostatic approach.

Patients are placed in the supine or low lithotomy position. The abdomen and genitalia are prepped in the field with a Foley catheter placed and accessible on the surgical field. Similar to females, an infraumbilical midline incision is used and can be extended superiorly if desired for bladder reconstruction. The rectus muscle is split in the midline and the space of Retzius is bluntly dissected. For patients undergoing salvage prostatectomy, this portion of the procedure is completed often with a wider excision of the prostate, as there is no urethrovesical anastomosis. This portion of the procedure is detailed in another chapter.

If the prostate is spared, the bladder neck is identified and the superficial dorsal venous complex is ligated with absorbable suture at the prostatovesical junction. Electrocautery is then used to incise the anterior bladder at the level of the prostate. The bladder is entered and Foley catheter is delivered into the field and secured. Again, the ureteral orifices are identified and catheterized. Allis clamps or traction sutures are used to secure the bladder neck. The posterior bladder neck is scored and transected with electrocautery and sharply dissected until the rectovesical space is identified. The posterior bladder neck is then completely mobilized off of Denonvilliers fascia until the bladder neck can be rotated anteriorly away from the urethra. If desired, the bladder can be reconstructed at this time or an SPT is placed in similar fashion to females as described earlier.

If the bladder neck is relatively small, two purse-string sutures may be used to invert the bladder mucosa. More often with larger bladder necks, closure is performed in two layers. Closure is again confirmed by filling the bladder via the SPT. An interposition graft with peritoneum, omentum, or rectus muscle is then placed at the urethral stump to prevent fistulas (Fig. 38.9). A drain is left in the pelvis away from the bladder neck and brought out through a lower abdominal stab incision.

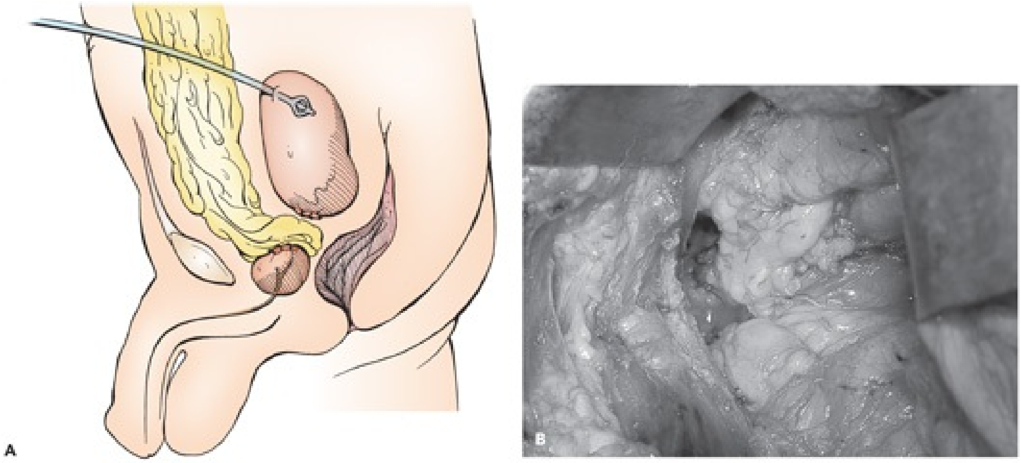

FIGURE 38.9 A: Omental interposition in the man. B: Photograph showing omental wrap over BNC to prevent secondary vesicourethral fistula.

POSTOPERATIVE CARE

Appropriate postoperative management is critical to success of abdominal or transvaginal closure of the bladder neck. Postoperative antibiotics are given for 24 hours. If the patient has bacterial colonization, consider a longer postoperative antibiotic course based on preoperative urine culture. Long-term prophylaxis if often used but not required. The bladder should be continuously draining with regular irrigation via the SPT and securing the SPT to the patient with avoidance of catheter plugging and kinking (13).

Equally important to adequate catheter drainage is management of detrusor overactivity. Although an SPT should allow for continuous bladder drainage, physiologically an open bladder neck may prompt a reflex bladder contraction (19). Higher pressures in the bladder put stress on the suture line, thus potentially increasing the risk of postoperative fistula formation. Administration of anticholinergics will potentially decrease this risk and should be used postoperatively (or continued if patient is already on them) (16). The use of onabotulinumtoxinA at the time of BNC has not yet been studied but presumably would allow for lower bladder pressures and further minimization of postoperative fistula formation.

A cystogram is performed approximately 3 weeks postoperatively to evaluate for fistulas. If the patient underwent bladder reconstruction and has a negative cystogram, the SPT can be removed. Patients with chronic SPT drainage should have their catheter changed every 4 to 6 weeks.

OUTCOMES

Results of series of BNC are difficult to compare because most studies are small and retrospective in nature with variable follow-up (9.6 to 78.6 months) and variable techniques (18,20). Fistula rates for transvaginal BNC range from 0% to 100% (13–15,20–23). Notably, the study with 100% fistula rate looked at only two patients who underwent transvaginal BNC (13). The largest study to look at the transvaginal approach initially included 50 patients, but at an average of 6.5 years follow-up, data was only available for 19 patients. These 19 patients had a fistula rate of 22% after primary repair, which decreased to 8% after revision (22). Overall, fistula rates drop to 0% to 25% after revision (14,20,22). Abdominal BNC fistula rates are notably lower with both primary repair (0% to 18%) and after revision (0% to 6%) (13,14,16–18).

Complications

Fistula formation is the primary complication of BNC and can occur immediately postoperatively or for up to 1 year. Fistulas are diagnosed by cystogram radiographically or by visualization of fluid emanating from the vaginal or perineal closure. Confirmation of a fistula can be done by instillation of indigo carmine mixed with contrast through the SPT to confirm the fistula radiographically and by direct inspection.

Conservative management with continued drainage for several weeks with frequent catheter irrigations and/or placement of bilateral percutaneous nephrostomy tubes may lead to fistula resolution (16). If a patient has a leak on cystogram with bladder filling but is clinically dry with SPT drainage as their primary mode of lower urinary tract management, these patients can usually be managed with regular SPT changes monthly and do not require further intervention unless the fistula progresses and becomes clinically relevant. For a mature fistula tract, repeat surgery may be considered. The choice of transvaginal versus transabdominal versus combined approach is at the discretion of the surgeon. If the repair is not salvageable, more invasive measures for urinary diversion may be considered including cystectomy with continent or incontinent diversion.

Other long-term complications after BNC include bladder stones, leakage from SPT site, SPT dislodgement requiring replacement, fistulas, and decrease in bladder compliance and increased risk of bladder cancer if bladder management is maintained with chronic catheter drainage.

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CHAPTER 39 ANTERIOR URETHRAL STRICTURE DISEASE

HUNTER WESSELLS

Urethral strictures have plagued men since antiquity, with descriptions in Indian literature dating as far back as 1000 BC. (1). The presentation of urethral stricture disease differs based on geographical, population, patient, and environmental factors, including prevalence of sexually transmitted infections, occupation of the workforce, and sophistication of health care systems (2). Despite etiologic variation, strategies to care for men with anterior urethral strictures depend less on pathophysiologic mechanism and more on accurate determination of the anatomic characteristics of the stricture including its location, length, luminal diameter, and previous treatment. The concept of a reconstructive ladder, in which progressively more invasive interventions are applied one after the other (3), has been supplanted by an individualized approach in which the best treatment for the stricture is delivered based on anatomic characteristics and probability of recurrence after treatment. Urethral stricture remains the province of surgeons, although innovations in stent technology and regenerative medicine (4,5) may one day allow treatment by minimally invasive proceduralists. Until that time, the care of patients with stricture disease requires a comprehensive and technically complex series of strategies to address the problems of poor tissue vascularization, prior irradiation, and spongiofibrosis; comorbid medical conditions; deficiencies in genital skin; and the unfortunate effects of repeated dilations or urethrotomies applied when success is unlikely (3).

This chapter summarizes the author's approach to the evaluation and treatment of anterior urethral stricture disease, with a focus on management across a spectrum of stricture complexity. The reader is encouraged to review the in-depth treatment of the subject in the International Consultation on Urethral Strictures (6) convened and published under the joint sponsorship of the Societe Internationale d'Urologie and the International Consultation on Urological Disease.

EPIDEMIOLOGY AND PATHOPHYSIOLOGY

Anterior urethral strictures are uncommon, accounting for approximately $200 million in direct medical costs per year (2). The average use rate for outpatient visits for stricture disease was approximately 274 visits per 100,000 U.S. population (range 200 to 1,200). Rate of utilization varies by healthcare context, age, ethnicity and other factors: reports among Veterans, Medicare beneficiaries, and the younger commercially insured population differ considerably (2,7,8). Although uncommon, treatment is costly, with strictures being responsible for incremental cost of treatment equaling $6,759 per patient. Additional economic impact of stricture disease derives from the fact that 25% of patients will miss work because of treatment (2).

The etiology of contemporary urethral stricture disease can largely be divided into traumatic, iatrogenic, inflammatory, and idiopathic (9). Pathophysiology will vary by age. Younger men will be more likely to have anterior urethral strictures due to straddle injury or complications from hypospadias surgery, whereas older patients will more likely suffer as a result of prior transurethral instrumentation. Of note, treatment for gonococcal urethritis with penicillin-based antimicrobial agents has effectively eradicated the complex debilitating bulbar urethral strictures previously associated with this disease. However, the emergence of multiply resistant strains of *Neisseria gonorrhoeae* may lead to resurgence in these cases worldwide. Lichen sclerosis (also known as balanitis xerotica obliterans) represents a particularly challenging cause of stricture disease with involvement of genital skin, progression to panurethral disease, and association with comorbidities such as obesity, which complicate treatment and surgery (10).

EVALUATION OF URETHRAL STRICTURE DISEASE

A careful history and physical examination allow the urologist to develop a reasonable understanding of the cause and possible complicating factors of an anterior urethral stricture. Urinary symptoms are the most common cause for presentation, with a reduction in the force of the urinary stream being characteristic. Both obstructive and irritative voiding occurs as a result of stricture disease, and thus questionnaires such as the American Urological Association (AUA) Symptom Index (11), which document these symptoms, have been used in characterizing and quantifying the severity of symptoms. However, these patient-reported outcome measures were not developed to identify the most relevant symptoms in men with stricture disease and do not necessarily address other domains of importance such as penile curvature, ejaculatory dysfunction, urinary incontinence, bother and impact, or responsiveness to treatment. Development of new instruments is an important need for the field (12,13).

Elements of the past history relevant to the cause of stricture and success of urethroplasty include presence of comorbid conditions such as obesity, diabetes mellitus, or severe peripheral vascular disease. A detailed surgical history is essential because of the potential for a stricture to develop as a result of endoscopic surgical manipulation such as transurethral resection of the prostate (14); abdominal perineal resection; and obvious etiologies such as previous urethroplasty, previous hypospadias surgery, or traumatic injuries to the penis or urethra. The personal and social history should be probed for evidence of cigarette smoking, which may significantly impair wound healing (15); long-distance bicycle riding or other sports leading to straddle injury; and risk factors for sexually transmitted infections. A complete review of systems is necessary to identify potentially significant conditions requiring assessment prior to surgery and anesthesia.

The physical examination focuses on the abdominal and genital region. Examination should assess potential bladder distention, presence of previous suprapubic cystostomy, hernia, and other abdominal scars. The phallus should be examined to determine whether the patient has been circumcised, or whether there is sufficient redundant shaft skin to allow creation of a penile skin flap, either circumferentially, based on the distal shaft skin, or longitudinally, based on a ventral skin island. The urethral meatus should be examined for stenosis and the surrounding skin of the glans for signs of lichen sclerosis. A shiny pallor of the glans and/or prepuce is characteristic. The corpus spongiosum should be palpated along its length to identify areas of intense stricture, abscess, or constriction. The scrotum and its contents should be examined. Hair distribution on both the penile shaft and the scrotum should be recorded when skin flaps are considered. Although scrotal skin flaps are no longer commonly used for urethral reconstruction, laser hair removal or other forms of epilation allow scrotal skin to be used in selected circumstances. Perineal and rectal examinations complete the pertinent regions of interest.

Laboratory studies are used selectively to identify associated urologic conditions including urinary tract infection and renal insufficiency. A urinalysis with microscopic evaluation will detect hematuria, pyuria, and bacteriuria. Because urethral strictures frequently cause microscopic hematuria, complete workup is not generally pursued unless persistent. Serum creatinine is not indicated unless signs of poor bladder emptying suggest a risk for renal deterioration.

Noninvasive urodynamic studies are a valuable adjunct to the assessment of urinary symptoms. Uroflowmetry provides a quantitative estimate of the degree of obstruction, which along with postvoid residual urine volume provides a gauge of the severity of urethral narrowing and efficiency of voiding. More formal pressure flow urodynamic studies are only indicated for the evaluation of complex cases. When concomitant prostatic obstruction and urethral narrowing are found, video urodynamics may successfully distinguish the anatomic point of obstruction.

Radiographic Studies

Contrast studies of the urethra are the cornerstone of appropriate and individualized management. The combination of retrograde urethrogram and voiding cystourethrogram allows appropriate delineation of the anterior urethra, accurate assessment of the length of the stricture and narrowing of the urethra, as well as the dynamic understanding of urethral caliber and function above the point of obstruction. Techniques for retrograde and voiding urethrography are beyond the scope of this chapter (16). However, several points require elaboration. A retrograde urethrogram is performed by positioning the patient obliquely at 45 degrees with the bottom leg flexed at the knee and the top leg kept straight. A 12Fr Foley catheter, Brodney clamp, or catheter-tipped syringe is introduced into the fossa navicularis, the penis is placed on gentle traction and 20 mL undiluted water soluble contrast material is injected. Retrograde urethrogram can underestimate the length of bulbar urethral strictures, potentially due to inadequate rotation or stretch of the penis (Fig. 39.1). The penis must be adequately stretched so that the pendulous portion of the penile urethra and the penoscrotal junction are appropriately visualized (Fig. 39.2). Voiding cystourethrography requires that the bladder be filled by retrograde instillation of contrast (Fig. 39.3), which may be challenging if the stricture is very stenotic or the external sphincter is tightly contracted.

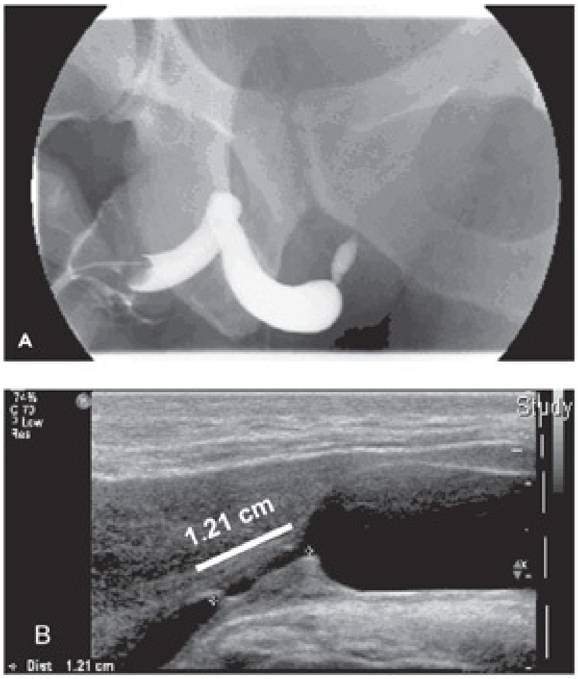


FIGURE 39.1 A: Retrograde urethrogram showing apparently short bulbar stricture. B: Intraoperative sonourethrogram showing corresponding length and narrowness of stricture demonstrating a 1.21-cm long stricture.

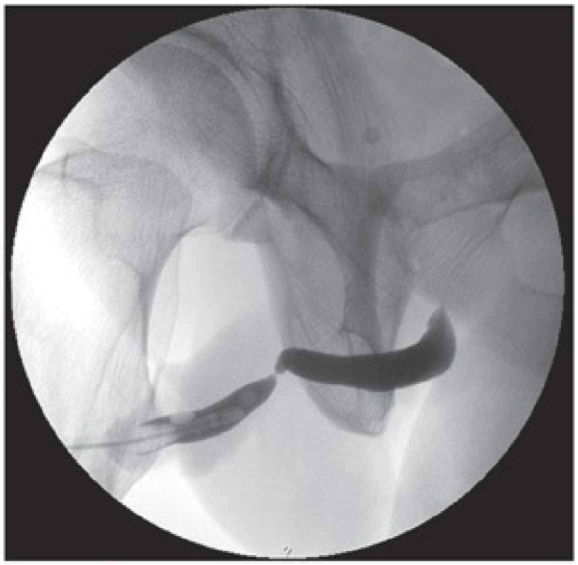


FIGURE 39.2 Retrograde urethrogram showing short stricture of penile urethra well visualized because of adequate rotation and stretch of urethra.

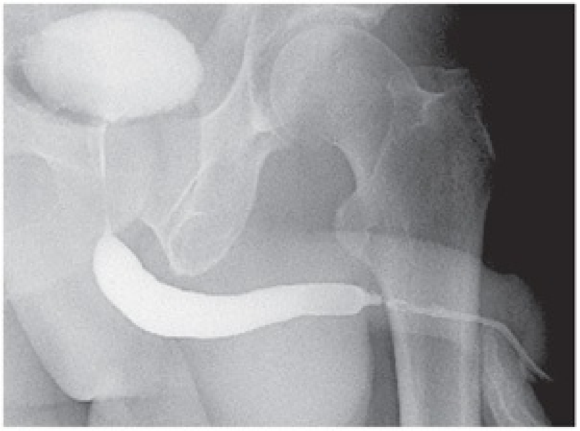


FIGURE 39.3 VCUG showing long penile urethral stricture. Note prostatic urethra narrowed because of concomitant benign prostatic hyperplasia.

Ultrasonography represents an adjunct to fluoroscopic modalities to assess anterior urethral strictures (17). Usually performed intraoperatively, the technique can clarify stricture length when upstream imaging is not possible on voiding cystourethrogram (VCUG), or when rotation of the patient impedes accurate measurement of the length of the stricture (see Fig. 39.1B). Additionally, estimation of the inner diameter of the urethral lumen can aid in deciding whether to perform excision and anastomosis of a portion of a longer stricture as part of augmented anastomotic urethroplasty (*vide infra*).

Endoscopic Studies

Cystoscopic evaluation of urethral stricture disease has a limited role in the diagnostic protocol. It serves an important initial evaluation of men with suspected urethral stricture disease, identifying the distalmost portion of the stricture. However, it cannot determine the length of the stricture nor assess the urethra proximal to the stricture. Further endoscopic evaluation is best reserved for several scenarios. An example is a stricture that cannot be fully visualized due to lack of retrograde filling of the urethra by obliteration or sphincteric spasm during the study. Specialized endoscopes such as a pediatric cystoscope or 8Fr ureteroscope can be used to examine strictures under these circumstances. Another indication is a rare case in which physical examination or other factors raise the suspicion of urethral cancer.

RECONSTRUCTIVE PRINCIPLES

Urethral reconstructive surgeons need to maintain an array of skills to allow transition from simple to more complex reconstructive strategies during the course of a surgical case. An apparently simple stricture will occasionally require more complex care than anticipated prior to surgery. For example, preoperative imaging of a bulbar stricture may underestimate its length, so that an initial anastomotic approach must be supplanted by free graft substitution urethroplasty, based on intraoperative findings, patient anatomy, and other factors. Similarly, a straightforward 3- or 4-cm bulbar urethral stricture, normally treated with ventral or dorsal onlay substitution urethroplasty, may in fact require staged approaches or additional grafts or skin flaps. Thus, it is only appropriate to embark on urethroplasty if one can offer the patient all necessary options and bring all appropriate techniques to the surgical procedure.

The key techniques include endoscopic incision; anastomotic techniques; dorsal and ventral substitution; free graft donor options including full thickness and split thickness skin, oral mucosa, and bladder epithelium; skin flap urethroplasty from penile or scrotal skin; local tissue rearrangement in the form of advancement flaps (YV-plasty, Z-plasty); and flaps for defect coverage such as gracilis muscle or smaller flaps such as dartos and tunica vaginalis.

Internal Urethrotomy

Internal urethrotomy is an important technique for the reconstructive urologist, based on the principle of healing by secondary intention described by Davis for ureteral strictures (18). Sachse (19) applied the concept to urethrotomy, using a cold knife to precisely incise the urethral epithelium under direct vision. Although few strictures are cured with direct vision internal urethrotomy (DVIU), recurrent strictures after urethroplasty can often be effectively treated by DVIU. In cases involving a prior flap or graft, or prior hypospadias surgery, techniques have been modified to create multiple shallower radial incisions (20).

Anastomotic Techniques

Excision and reanastomosis is an essential tool for anterior and posterior urethral reconstruction. Knowledge of the anatomy of the corpus spongiosum (Fig. 39.4) is essential to safely take advantage of the antegrade and retrograde blood supply provided by the bulbourethral and dorsal arteries, respectively (21). The ability to mobilize the urethra, excise portions of it, and reapproximate underlies successful primary anastomosis as well as a variety of augmented approaches (22) in which excision of a portion of the stricture, and reanastomosis, is combined with tissue transfer using a graft or flap (23). In addition to preservation of the longitudinal intrinsic blood supply of the corpus spongiosum, anastomotic urethroplasty requires assessment of the appropriate degree of tension that may be placed on the anastomosis. A rule of thumb in the bulbar urethra is that strictures 1 to 2 cm in length can be bridged with excision and primary anastomosis (EPA). This assumes that the remaining urethra is normal, compliant, and able to undergo elongation to bridge a gap. In cases of proximal bulbar strictures, the uninvolved urethra, if completely normal, may be capable of significant elongation beyond 2 cm (24). The ability to reduce the gap between the ends of the urethra is dictated in part by the location of the gap. In the more proximal bulbar urethra, division of the corporal bodies is a maneuver to reduce the distance between the two ends for tension-free anastomotic urethroplasty. With longer strictures associated with spongiofibrosis of significant portions of the urethra, the behavior of the remaining urethra under stretch may be different. It may not be possible to bridge a 2-cm defect. Thus, augmented anastomotic approaches typically involve excision of shorter portions of the urethra. Likewise, in the penile urethra, the elasticity of the urethra is significantly less, and only short defects can be bridged with EPA.

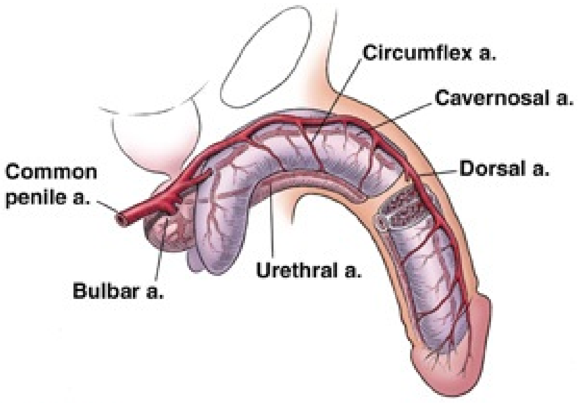


FIGURE 39.4 Blood supply of penis and urethra. (Reprinted with permission from Jordan GH, McCammon KA. Surgery of the penis and urethra. In: Wein AJ, ed. *Campbell-Walsh Urology*, 10th ed. Philadelphia: Saunders/Elsevier, 2011. Copyright © 2011 Elsevier Health Science Books.)

Free Grafts

Free grafts have been used for reconstruction of complex anterior urethral strictures since the 1960s (25). Full-thickness skin grafts from the prepuce or penile shaft fare well in substitution urethroplasty, although early indications for severe complex strictures exceeded the limits of the technique. The evolution of stricture etiology away from gonococcal infection, with its severe spongiofibrosis, to less complex strictures supports the greater use of free grafts. No prospective study has definitively shown inferiority of full-thickness genital skin to oral mucosa, although a recent meta-analysis found higher odds of recurrence with penile skin (26). Nevertheless, the ease of harvesting, suppleness of the oral tissues, intrinsic acceptance of the moist environment, lesser donor site morbidity, and other factors accelerated the adoption of buccal mucosa as the preferred free graft for substitution urethroplasty. Use of bladder epithelium and full-thickness skin should be considered for specific cases in which pathology of the oral mucosa, paucity of donor sites within the oral cavity, or other factors make oral mucosa unavailable. With any free graft, donor site morbidity and characteristics of the graft must be taken into account in a surgical plan. For example, defatting a full-thickness skin graft is straightforward: Shiny undersurface of the dermis allows for simple and rapid defatting. In contrast, the buccal mucosa harvesting as reported in the literature invites greater variation in technique, for example, relating to the depth of defatting that occurs (27). Such factors may affect outcomes of graft take. Lastly, bladder mucosa has a very thin lamina propria and is extremely pliant, making it unsuitable for meatal reconstruction or staged procedures with exteriorization of the neourethra. Full-thickness skin from the genitalia is relatively thin yet nevertheless does not suffer from substantial contraction. In contrast, split-thickness skin grafts will contract more significantly, limiting their application in all but the most severe and complex reconstructive scenarios.

Skin Flaps

Vascularized skin flaps, once a workhorse of anterior urethroplasty, have become less prevalent due to the increased adoption of buccal mucosa free graft urethroplasty, rise in prevalence of strictures related lichen sclerosis, and lack of sufficient genital skin in many circumcised men. Nevertheless, the island skin-flap approach to urethroplasty remains important, particularly in reoperative cases with extensive spongiofibrosis and poor graft fed characteristics (Fig. 39.5), such as postirradiation, posttraumatic, or postinfectious scenarios (28). Whether a circumferential distal penile flap (e.g., circular fasciocutaneous flap) or a longitudinal ventral flap, the principles are similar. A paddle of skin, which will not contract, is marked out on stretch, so that the exact dimensions of the flap are cut and used during the surgery. Preservation of the pedicle and its blood supply is based on the tunica dartos, either through random vascularity or a specific pedicle. Adequate mobilization of the pedicle is required to transfer the tissue into the appropriate recipient site, whereas preservation of the intrinsic blood supply of the overlying shaft skin prevents necrosis or complications of the donor site. Circular distal flaps (29), whether harvested from the prepuce (uncircumcised) or the distal shaft skin (circumcised), allow up to 15 cm length of skin to be transferred and create a pedicle which can reach all the way into the perineum for the very most proximal bulbar, membranous, and prostatic strictures.

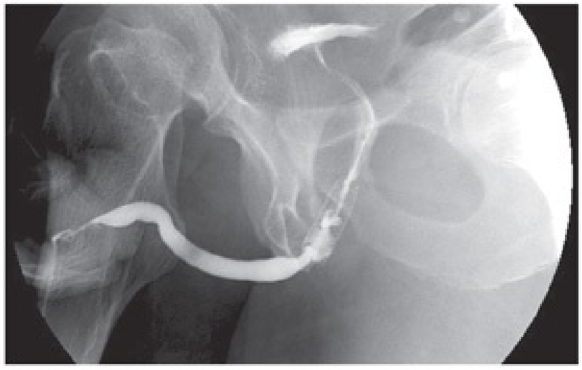


FIGURE 39.5 Retrograde urethrogram showing severe stricture within metallic stent in the proximal bulbar urethra of a previously radiated patient. The stricture was treated with stent removal and skin flap urethroplasty.

Flaps for Coverage

In cases of primary urethroplasty, adjacent tissue such as the tunica dartos or bulbospongiosus muscle can provide for graft vascularization and protection against urethrocutaneous fistulization. However, with reoperative surgery, staged surgery, or other cases in which the graft bed is compromised, the urethra lacks coverage options locally. Due to space constraints on the penile shaft, less bulky coverage flaps such as tunica dartos or tunica vaginalis are required. A potential obstacle to the use of dartos is previous hypospadias surgery. The rearrangement of skin and underlying dartos presents particular technical challenges to mobilization, although these can be successfully navigated (29). For such patients, rearrangement of the tunica vaginalis of the scrotum to bring it up alongside the penile urethra may be the best option (30). In contrast, the perineum can accommodate placement of a gracilis muscle flap in cases of extreme tissue deficit or postradiation cavities.

PREOPERATIVE AND INTRAOPERATIVE DECISION

MAKING

Patient and stricture characteristics dictate the surgical approach necessary to achieve the desired outcome for an individual patient. Except in cases of strictures complicated by urinary retention and/or urethral obliteration, the decision to proceed with urethroplasty versus another approach to a specific urethral stricture is heavily driven by patient expectations and goals. In young men, one may recommend definitive procedures to achieve complete resolution of urinary symptoms, whereas in elderly or debilitated patients, strictures are more likely to be managed in an expectant or “custodial” manner. In all cases, the individual patient goals and circumstances will necessarily be considered.

A brief algorithm for the treatment for urethra strictures is shown in Figure 39.6. For a first-time bulbar stricture less than 1 cm in length, a cost-effectiveness perspective indicates that a single attempt at DVIU is usually recommended prior to urethroplasty (31). The success rates for dilation or internal urethrotomy for short bulbar strictures ranges from 30% to 80% (see summary in Wright et al. [31]) and our approach is, under most circumstances, to proceed with DVIU. Exceptions include individuals in whom a prior straddle injury, and its associated full-thickness spongiosal fibrosis, makes the probability of success with DVIU much lower (Fig. 39.7).

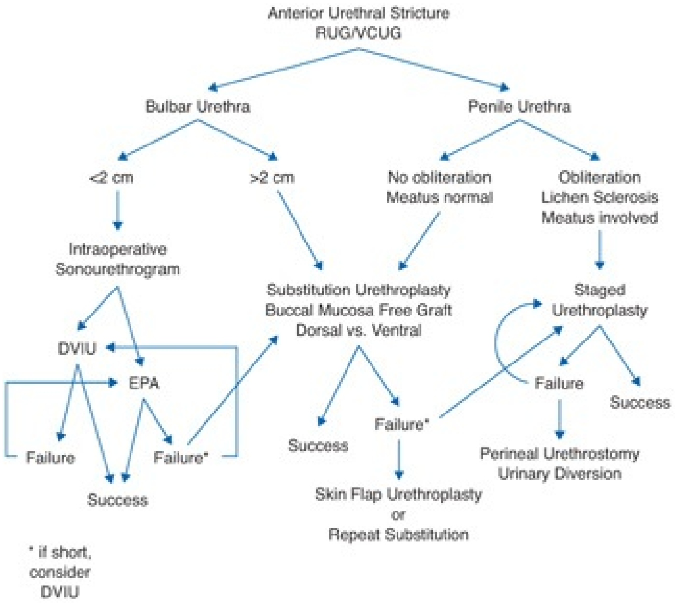


FIGURE 39.6 Algorithm for the management of anterior urethral stricture. *DVIU*, direct vision internal urethrotomy; *EPA*, excision and primary anastomosis; RUG, retrograde urethrogram; *VCUG*, voiding cystourethrogram.

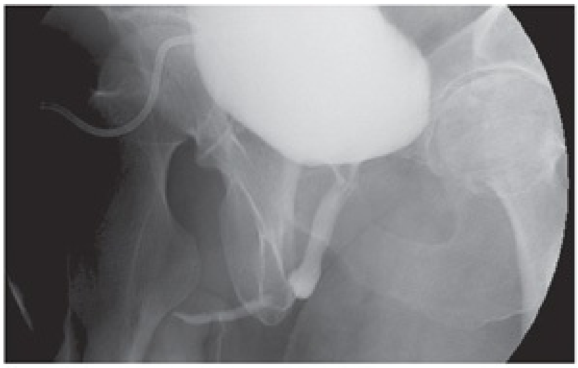


FIGURE 39.7 Short very narrow stricture after straddle injury not suitable for DVIU.

Bulbar urethral strictures between 1 and 2 cm in length are optimally treated with EPA, yielding success rates >95% (31). DVIU for a 2-cm bulbar stricture is very unlikely to yield a successful outcome and theoretically can change the stricture from one amenable to EPA, with overwhelmingly successful outcomes, to a longer stricture requiring substitution. Thus, these individuals should proceed to urethroplasty except under exceptional circumstances. A variety of centers have advocated for alternative surgical approaches to these short strictures, such as “nontransecting bulbar urethroplasty” based on the rationale that the odds of erectile dysfunction after EPA is higher than after substitution urethroplasty (32,33). These reports, however, do not contain sufficient evidence to counterbalance the success of EPA and the generally accepted low rate of erectile dysfunction after urethroplasty, which was 1% in a recent meta-analysis (34).

Strictures greater than 2 cm in length in the bulbar urethra, and any substantial length in the more distal urethra (e.g., Fig. 39.2), require substitution urethroplasty. This generally will be a buccal mucosa free graft using either a ventral or dorsal onlay, although a skin flap (Fig. 39.8) will provide comparable outcomes in the absence of lichen sclerosis or other processes affecting the genital skin (23,35).

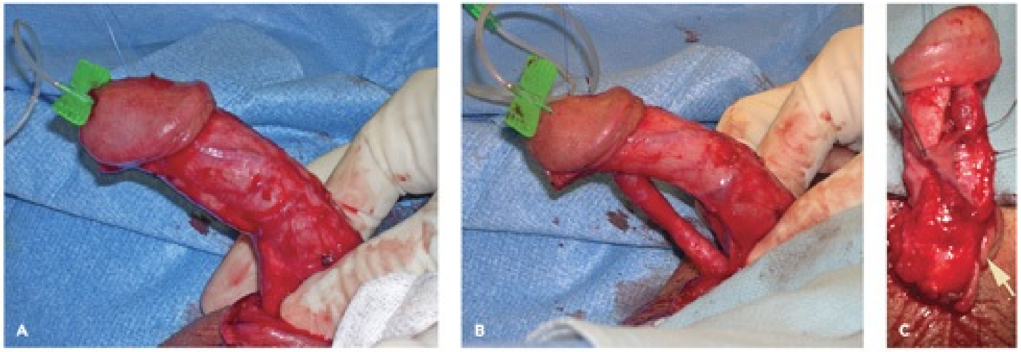


FIGURE 39.8. **A and B:** Penile urethral stricture due to instrumentation (same as Fig. 39.2) causing chordee treated in this case with skin flap urethroplasty (and penile plication for curvature). **C:** *Arrow* shows pedicle of flap rotating around base of penis. Dorsal onlay substitution with free graft could also be considered.

An important exception to these general recommendations is when a segment of a longer urethral stricture is obliterated or nearly completely obliterated (Fig. 39.9). Excision of the most severe portion of the stricture, with ventral or dorsal reanastomosis and free graft reconstruction (augmented anastomotic urethroplasty [22]) offers an effective solution while avoiding excessive urethral removal with its resultant chordee and shortening.

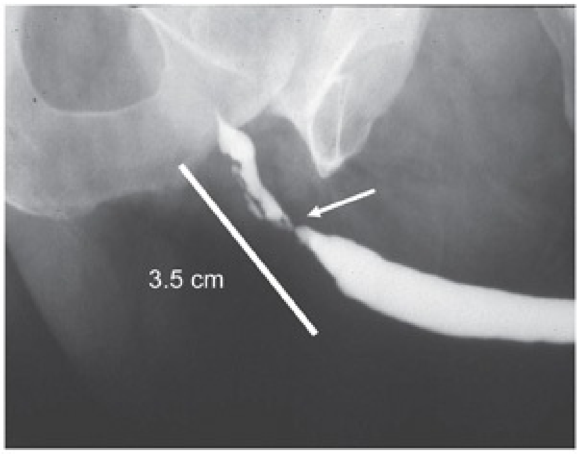


FIGURE 39.9 Dense proximal bulbar stricture with short nearly obliterated segment (*arrow*). The length exceeds that for EPA and thus substitution urethroplasty will be necessary.

Finally, with very long segments of urethral narrowing or obliteration, staged procedures are required. These techniques have been developed in response to the poor outcomes with tubularized free grafts, in which the graft bed fails to vascularize the tubularized tissue transfer (36). In these cases, placement of the free graft directly on a flat vascularized surface, such as the tunica albuginea of the corpora cavernosa, tunica dartos, or tunica vaginalis allows effective, stable bed engraftment and staged tubularization once new collateral vascularity has formed.

GENERAL CONSIDERATIONS IN URETHRAL RECONSTRUCTION

Patient Positioning

The majority of patients undergoing bulbar urethroplasty require placement of the lower extremities in the lithotomy position. Because of the rare but serious risk of neurapraxia and compartmental syndrome (37,38), an experienced member of the surgical team should supervise and approve final lithotomy positioning. Rarely is the exaggerated position required for anterior urethral strictures. Stirrups that provide rotational and longitudinal adjustments in addition to padding are preferred to minimize pressure against the lateral calf in the region of the peroneal nerve and ensure sufficient extension of the knee joint. Factors proposed to influence risk include use of Trendelenburg, knee position, external compression for deep vein thrombosis prophylaxis, method of leg support, duration of surgery, and other measures including age and body mass index (39).

Antibiotic Prophylaxis

The colonization of the urethra by bacteria classifies urethral surgery as clean contaminated and thus at risk for surgical site infection, urinary tract infection, and generalized sepsis. Thus, all instrumentation of strictures, whether endoscopic or open, requires antibiotic prophylaxis. According to AUA Guidelines, DVIU and dilation are appropriately covered by a quinolone antibiotic (40). For open urethroplasty, a first-generation cephalosporin is sufficient. Perioperative antibiotic administration ceases within 24 hours; oral antibiotic administration at time of catheter removal is recommended.

Urethral Sonography

Sonography, as described earlier, may serve as an adjunctive diagnostic test to accurately differentiate between strictures of the bulbar urethra that require DVIU, EPA, or substitution according to the length or diameter of the stricture. After induction of anesthesia, sterile saline is injected at the meatus using a Toomey syringe and concomitant suprapubic pressure is applied to maximize urethral distension. A 7.5- to 12-MHz probe placed on the perineum is then used to image the urethra longitudinally, measuring stricture length and narrowest luminal diameter.

Buccal Mucosal Harvest

We generally harvest a 6 cm × 2 cm segment of oral mucosa from one or both inner cheeks. Briefly, three stay sutures are placed at the lateral aspect of the mouth, and a Jennings mouth gag is used to open the mouth widely. The graft is marked out (Fig. 39.10) taking care to identify and preserve Stensen duct. Bupivacaine with 1:100,000 epinephrine is injected below the submucosa as a form of hydrodissection. The graft edges are then sharply incised with a scalpel and the graft is dissected off of the buccinator muscle with scissors. Bleeding points are cauterized and epinephrine-soaked gauze is packed into the defect. We do not close the defect because evidence suggests less pain and morbidity occurs (41). Graft take depends on imbibition of nutrients for 24 to 48 hours until inosculation occurs. Thus, fat and muscle are removed from the graft as shown in Figure 39.11. When additional oral mucosa is required, harvesting from the undersurface of the tongue (42) is preferred to the lip, the latter being associated with increased morbidity of the donor site in our hands (e.g., deformation of lip).

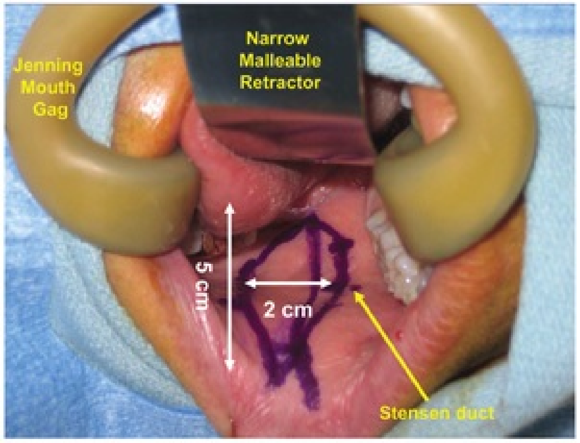


FIGURE 39.10 Buccal mucosa donor site. Note Stensen duct adjacent to second molar tooth (*long arrow*). Width is between 2 and 3 cm depending on type of urethroplasty planned.

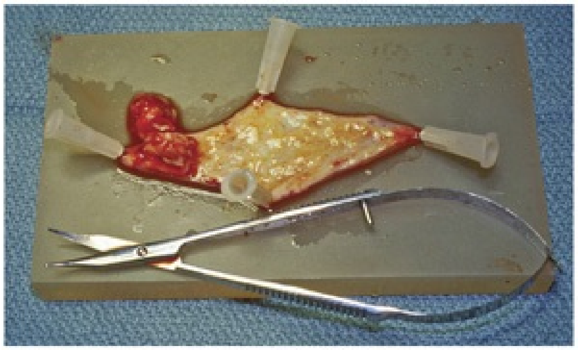


FIGURE 39.11 Defatting a buccal mucosa graft.

Postoperative Care

The vast majority of patients undergoing urethroplasty can be discharged within 24 hours. Routine catheter care and limited physical activity are recommended until the catheter is removed. A VCUG or pericatheter retrograde urethrogram is performed after substitution urethroplasty or if the repair is complex, and if persistent extravasation is noted, the catheter is replaced (VCUG) or kept in place (pericatheter study). Routine imaging is not recommended for DVIU or EPA due to the very low risk of extravasation or complication with early catheter removal (43). A schedule for catheter removal and follow-up care is proposed in Table 39.1. We do not use pharmacologic methods to inhibit erection in the postoperative period but do instruct patients to refrain from sexual activity for 4 to 6 weeks after surgery. Perineal precautions limit pressure on the repair for the first several weeks and prohibit bicycle riding for 3 months.

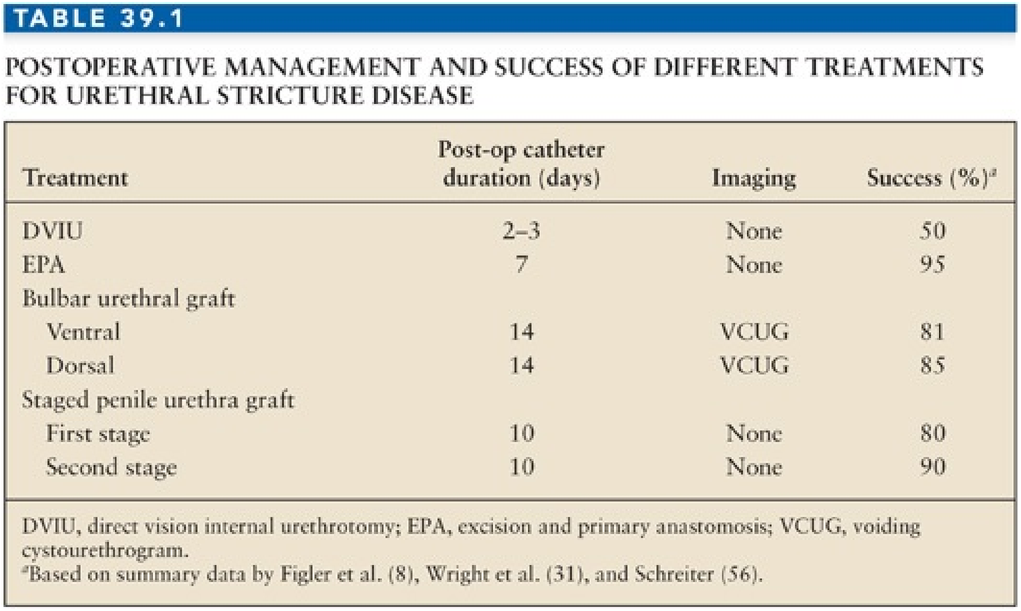


TABLE 39.1

POSTOPERATIVE MANAGEMENT AND SUCCESS OF DIFFERENT TREATMENTS FOR URETHRAL STRICTURE DISEASE

Treatment	Post-op catheter duration (days)	Imaging	Success (%)[a]
DVIU	2–3	None	50
EPA	7	None	95
Bulbar urethral graft			
Ventral	14	VCUG	81
Dorsal	14	VCUG	85
Staged penile urethra graft			
First stage	10	None	80
Second stage	10	None	90

DVIU, direct vision internal urethrotomy; EPA, excision and primary anastomosis; VCUG, voiding cystourethrogram.

[a] Based on summary data by Figler et al. (8), Wright et al. (31), and Schreiter (56).

SURGICAL TECHNIQUES

Direct Vision Internal Urethrotomy

For definitive treatment of a short urethral stricture, incision is made through the full thickness of the stricture into healthy corpus spongiosum to promote healing by secondary intention. The standard approach to DVIU uses the cold knife technique described by Sachse (19). For very tight or long stenoses, wire access can provide guidance for catheter placement. For cases in the penile urethra or where multiple small cuts in a stricture are advisable (see following text), an 8Fr pediatric resectoscope with cold knife urethrotome compares favorably to the diameter of an adult urethrotome sheath (typically 20Fr), mitigating iatrogenic injury. Laser DVIU provides comparable results to cold knife (44) but is not recommended due to the additional cost without benefit (45).

Short-term urethral catheterization is advisable to control venous bleeding, with most studies advising 3 to 10 days of catheterization. We advocate a short period (48 to 72 hours) or until the urine is clear. No benefit has been attributed to longer duration of catheterization. Adjunctive use of intermittent catheterization to enhance the success of DVIU has assessed through small retrospective series and in one negative randomized controlled trial (RCT) (45). Although not shown to reduce stricture recurrence rates, the use of intermittent self catheterization (ISC) is recognized as a means to provide palliative management of a stricture in patients unwilling or unable to undergo urethroplasty (46).

Bulbar Urethra

DVIU for urethral stricture is classically performed at the 12 o’clock position (20). This makes particular sense in the bulbar urethra, to avoid potential injury to the urethral arteries, which are typically located at 3 and 9 o’clock. The incision also avoids the thickest portions of the corpus spongiosum ventrally, thus reducing the likelihood of significant bleeding.

Penile Urethra

Because of the limited spongiosal thickness and higher risk of extravasation, we generally recommend urethral dilation of penile strictures rather than DVIU. Dilation should proceed over a stiff wire to prevent false passage, using either a balloon dilator or other methods of progressive dilation (e.g., Goodwin sounds). Penile urethral strictures after prior hypospadias surgery present a particular challenge because of the absence of spongiosum in many cases. Such tubularized skin urethras are easily disrupted with dilation or DVIU. Reconstruction should be considered for recurrence after such an endoscopic attempt, unless the patient is willing to adopt intermittent self-catheterization as a chronic management strategy.

Post-urethroplasty

After substitution urethroplasty, stricturing typically occurs at the proximal or distal end of the graft. Strictures after EPA will be located at the site of anastomosis. If soft and focal, it has been our preference to make radial incisions that do not extend as deeply into the spongiosum. For such cases, we use a pediatric scope as described previously.

EXCISION AND PRIMARY ANASTOMOSIS

Appropriate stricture length for EPA (Fig. 39.12) can be ascertained with retrograde urethrography and confirmed with ultrasound immediately prior to surgery or by intraoperative measurement. After positioning the patient in the lithotomy position, a midline perineal incision is carried out through skin and Colles fascia. Electrocautery is used to divide fat down to bulbospongiosus muscle, which is split in the midline. After defining the ventral bulb, we identify the location of the stricture by passing a 20Fr catheter to the point of obstruction. We gain circumferential control proximal and distal to the stricture and sharply transect the urethra distal to the stricture. Working proximally, the stricture is excised, exposing healthy proximal spongiosum and a normal urethral lumen. Mobilization of the proximal and distal ends ensures a tension-free anastomosis with adequate vascular inflow. Rarely, previous urethral surgery such as distal hypospadias surgery, or a more proximal anastomotic urethroplasty, may compromise the ability to safely mobilize a segment of the urethra, and indicate the need for a substitution procedure. We spatulate the proximal end dorsally and distal end ventrally for approximately 0.5 cm. The anastomosis is started by securing the back wall in a single layer with five sutures, placing the knots on the inside of the urethra with a 5-0 absorbable monofilament. For the ventral wall closure, we switch to a two-layer closure (47). The first layer consists of a sufficient number of sutures through the mucosa, catching just a bit of the spongiosum. A second layer of sutures closes the tunica of the spongiosum. We close perineum in multiple layers of interrupted 3-0 or 4-0 absorbable sutures. Drains are reserved for persistent diffuse oozing.

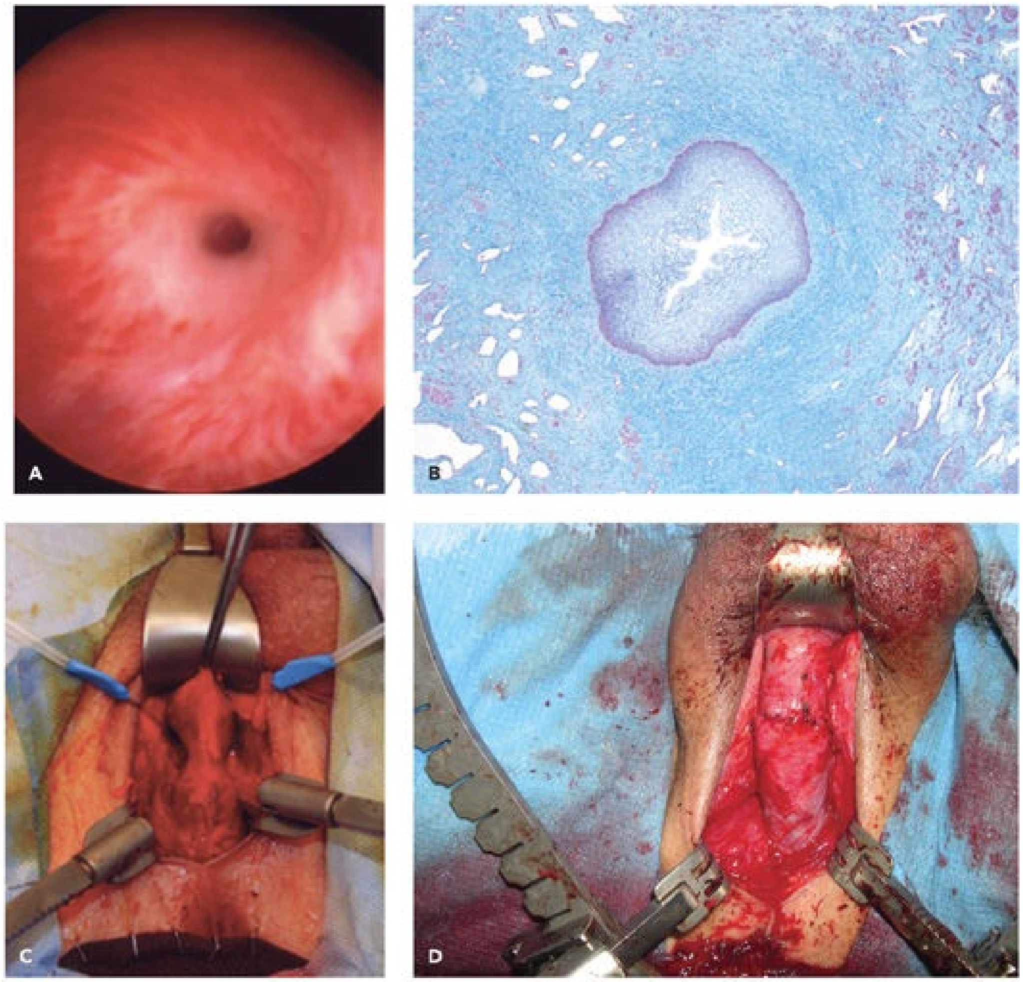


FIGURE 39.12 Short dense stricture treated primarily with EPA. **A:** Endoscopic appearance. **B:** Histologic appearance showing extensive fibrosis (blue color on histology). **C:** Narrowed corpus spongiosum at site of stricture. **D:** Final appearance of corpus spongiosum after anastomosis and closure of tunica.

SUBSTITUTION URETHROPLASTY

A decision must be made regarding the choice of tissue transfer (skin flap versus free graft) and location of onlay, either ventral or dorsal (8,23,35,48). Free graft substitution is favored for most complex bulbar and penile urethral strictures, although selected indications for skin flap urethroplasty remain.

Ventral onlay free graft substitution relies on an adequate ventral corpus spongiosum for its graft bed, which restricts the technique to strictures of the bulbar urethra. In contrast, because dorsally placed grafts rely on the tunica albuginea of the corpora cavernosa for their recipient bed, dorsal onlay can be applied to strictures in the bulbar and penile urethra. One meta-analysis suggested that dorsal onlay provides higher success rates compared to ventral (96% versus 85%), although in our hands, the rates of success were not statistically different (85% versus 81%) (8).

Ventral Onlay Graft

The distal extent of the stricture is identified by gently passing a 20Fr catheter until it meets resistance. Stay sutures of 4-0 are placed through the tunica of the corpus spongiosum parallel to the urethra, at the level of the catheter tip. Using a no. 15 blade, the corpus spongiosum is incised in the ventral midline until the catheter tip and urethral lumen are exposed (Fig. 39.13). The stricture is then incised along its entire length by extending the urethrotomy proximally. Full-thickness stay sutures are placed at close intervals for hemostasis and to aid in later identification of the mucosal edges for anastomosis. Once the entire stricture has been incised, the length and width of the remaining urethral plate are measured. Preservation of the urethral plate allows use of an onlay technique, which has superior outcomes when compared to full circumferential tubularized replacement of the urethra.

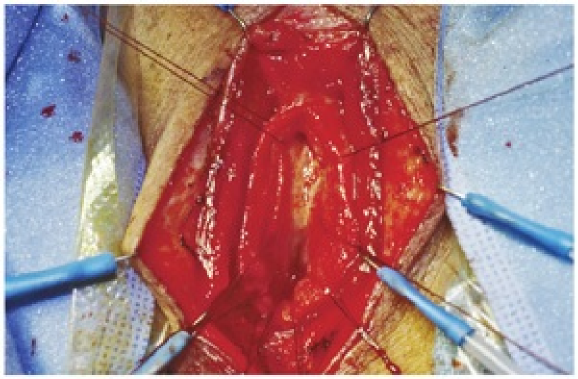


FIGURE 39.13 Ventral urethrotomy in anticipation of ventral onlay substitution urethroplasty.

Proximal and distal calibration of the urethra is critical to identify any residual narrowing. The graft is trimmed to its appropriate size allowing a urethral lumen of 28Fr when possible. Taking into account the modest graft contracture with oral mucosa (15% in one study by Sullivan, 2003 [49]), this usually requires a 2-cm wide graft. One end of the graft is anastomosed to the proximal apex of the urethrotomy with a series of interrupted sutures; 5-0 absorbable monofilament is used to complete a watertight anastomosis along each side of the graft. The proximal lumen is calibrated with bougies to ensure an adequate lumen and a 16Fr urethral catheter is placed prior to closing the distal portion of the urethra. After completion of graft suturing, the corpus spongiosum is closed over the graft with interrupted 4-0 absorbable sutures (Fig. 39.14). If a portion of the stricture is extremely fibrotic or narrow, excision of that portion of the stricture and dorsal reanastomosis should be performed in conjunction with grafting (Figs. 39.15 to 39.18). The bulbospongiosus muscle is reapproximated and Colles fascia and the skin are closed with interrupted absorbable sutures.

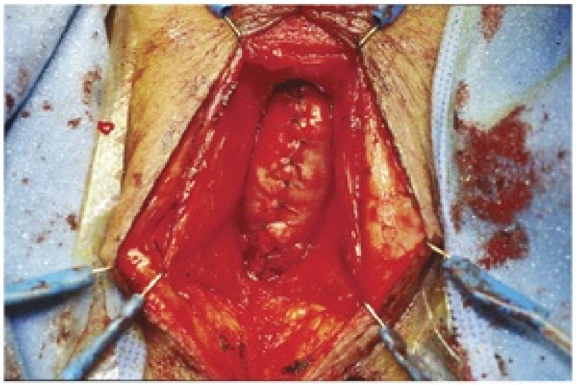
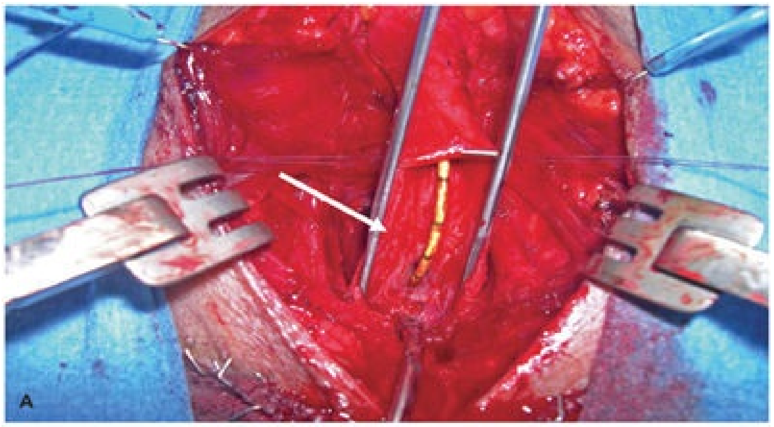


FIGURE 39.14 Completed spongioplasty after ventral onlay free graft.



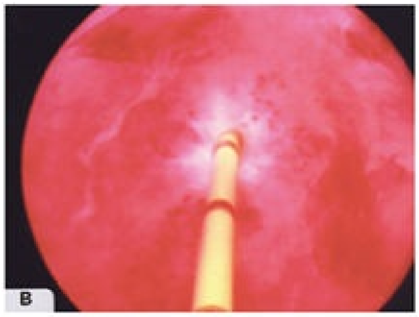


FIGURE 39.15 **A:** Augmented anastomotic urethroplasty by ventral onlay for a long bulbar urethral stricture. *Arrow* shows spongiosum after ventral urethrotomy. **B:** Endoscopic appearance of a very tight segment of a longer stricture.

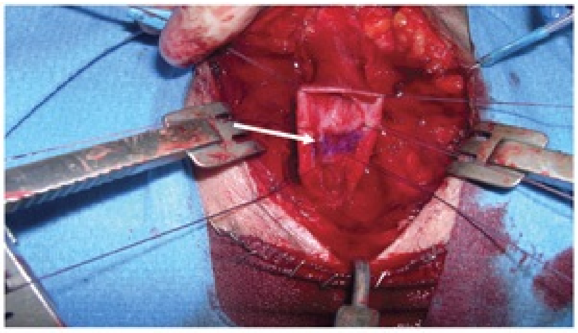


FIGURE 39.16 Segment of obliteration, with no visible mucosa, marked with ink for excision (*arrow*).

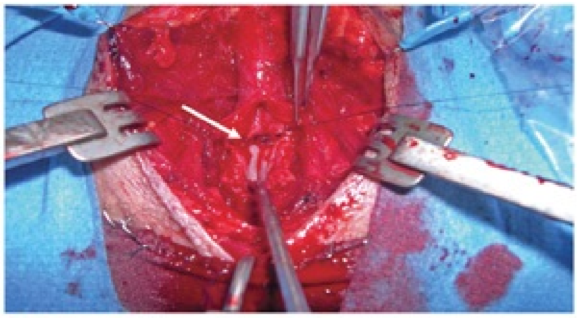


FIGURE 39.17 Reapproximation of dorsal urethral plate (*arrow*) after excision of portion of stricture, the so-called "roof strip anastomosis."

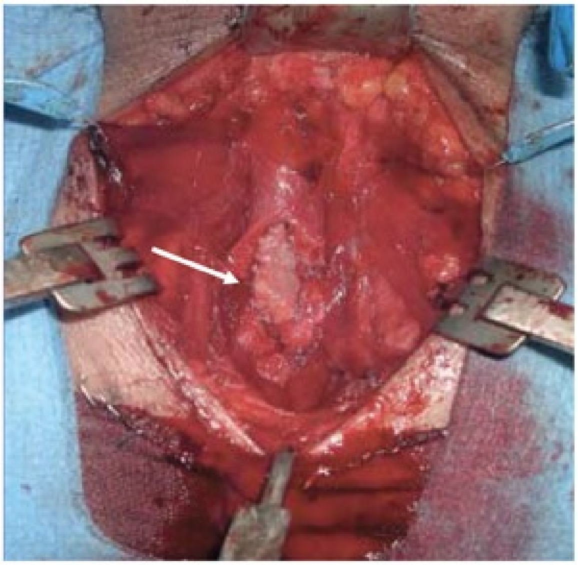


FIGURE 39.18 Ventral placement of buccal mucosa free graft (*arrow*).

Dorsal Onlay Graft

Dorsal graft placement is performed similar to the technique described by Barbagli et al. (50) and Iselin and Webster (51). The urethra is mobilized circumferentially off of the corporal bodies and incised dorsally throughout the length of the stricture into healthy mucosa at each end, which is calibrated to 28Fr. For patients in whom a portion of the stricture is excised (Figs. 39.19 and 39.20), the ventral urethra is reanastomosed with interrupted 5-0 monofilament prior to grafting. Once tailored, the buccal graft is "spread-fixed" to the corpora cavernosa. Approximation of the urethra to the graft along the entire length of the urethrotomy is performed with 5-0 absorbable monofilament sutures.

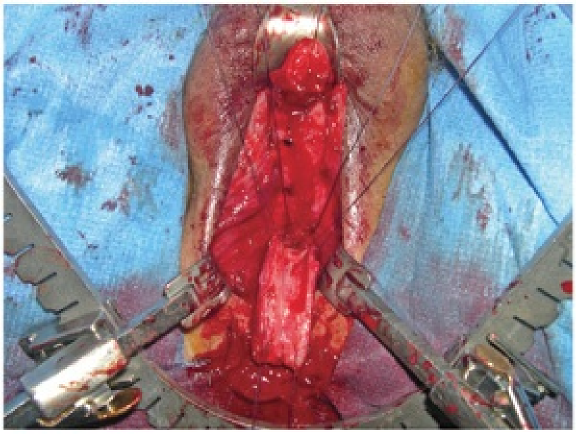


FIGURE 39.19 Augmented anastomotic urethroplasty by dorsal onlay for a long bulbar urethral stricture. The urethra has been transected and the tunica albuginea is exposed. The two ends of the urethra are shown.

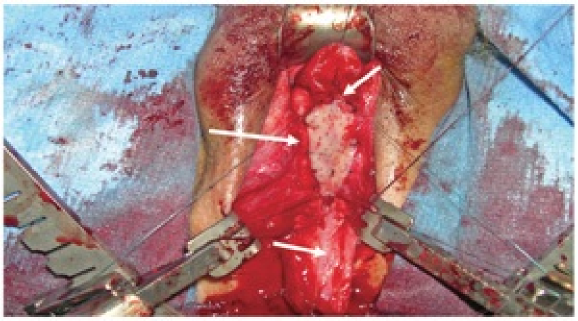


FIGURE 39.20 The buccal mucosa free graft has been spread fixed to the tunica (*long arrow*) and the proximal and distal anastomoses to the urethra have been completed (*short arrows*). Reapproximation of the urethral plate ventrally will be completed next in a so-called "floor strip anastomosis."

A specialized modification of the dorsal onlay addresses very long strictures involving both the bulbar and penile urethra. Pioneered by Kulkarni et al. (52), the entire urethra is approached from a perineal incision, invaginating the penis to expose the distal urethra, and only mobilizing one side of the surrounding muscle and corpus spongiosum. The authors describe techniques that allow placement of the graft into the fossa navicularis and even to the meatus (52).

Penile Skin Flap

Penile shaft skin can be mobilized in a variety of configurations to allow a vascularized tissue transfer into the urethra. Contraindications exist, including lichen sclerosis or premalignant lesions, buried penis configuration, and a lack of hairless skin. Parallel circumferential incisions are marked on the penile shaft. The skin should be stretched flat when marking the incision to avoid a redundant flap. The distal line should be 0.5 cm from the coronal margin. The width of the flap depends on the nature of reconstruction. In general, a flap width of 2 cm is adequate for onlay repairs because the skin will not contract. The flap should be individually tailored to the width of the urethral plate and length of the urethrotomy.

The incisions through the skin are made around the complete circumference of the penis (Fig. 39.21) unless the stricture is short and ventral mobilization alone will suffice. We begin by deepening the distal incision to the level of Buck fascia. Once the dorsal neurovascular bundle is identified, one can be confident that Buck fascia lies below the plane of dissection. Ventrally, the plane of dissection runs right above the corpus spongiosum. Once the deep plane of dissection is completed, one can then develop the superficial plane between the dartos fascia and the skin. Dissection is begun at the proximal skin incision between the skin and the pedicle. A thick fascia pedicle should be created, but care must be taken that visible superficial vessels remain with the skin. This superficial plane of dissection is carried proximally to the base of the penis.

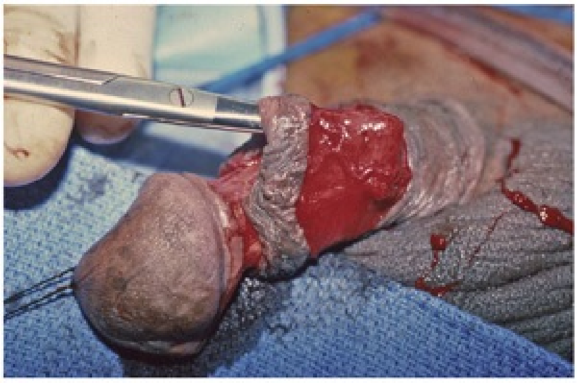


FIGURE 39.21 Circular penile skin flap on a dartos pedicle.

After developing the circular island of skin, midline division of the skin and pedicle allows rotation of the flap around the penile shaft. The skin island can be based on either a dorsal or ventral pedicle and provides up to15 cm of skin (Fig. 39.22).

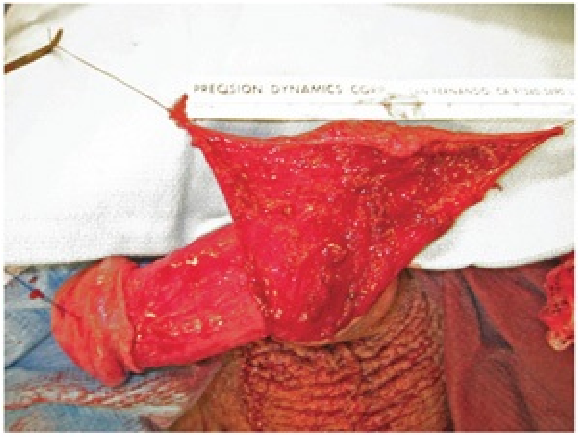


FIGURE 39.22 Circular penile skin flap after division of the skin and pedicle.

STAGED URETHROPLASTY

Strictures causing obliteration or severe fibrotic involvement of the fossa navicularis (Fig. 39.23) or long segments of the penile (or rarely bulbar) urethra may require complete removal, and in these cases, standard anastomotic and substitution procedures are not feasible. Bracka (2000) (53) and Mundy (54) have described a staged approach in such cases. Alternatives include definitive perineal urethrostomy, combined dorsal and ventral grafting, or other individualized strategies. However, for the most severe strictures, the staged approach provides a conservative means to remove severe spongiofibrosis, correct residual chordee, and assure proper graft take and healing prior to tubularization (55).

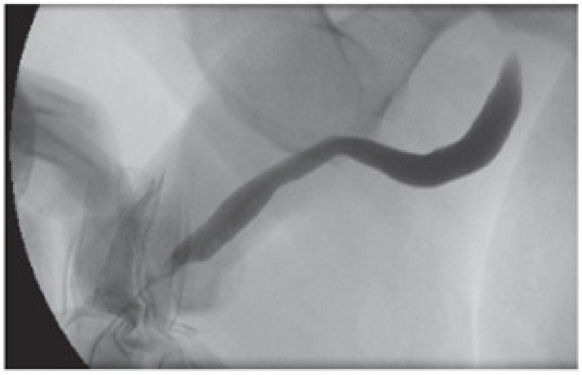


FIGURE 39.23 Retrograde urethrogram showing short severe stricture in distal penile urethra/fossa navicularis.

First Stage

After exposing the distal corpus spongiosum through a midline ventral penile incision, mobilization of the strictured urethra follows. The entire spongiosum is freed off of the underlying corporal bodies. Complete understanding of the stricture extent and severity before committing to a staged substitution is essential. Urethra with little to no luminal diameter is best excised, thus leaving a defect. Buccal mucosa is harvested as described earlier and fenestrated with an 18-gauge needle to prevent seroma formation. The dimensions of the graft are tailored to the length of the defect, allowing a minimum width of 25 to 30 mm. The graft is “spread-fixed” laterally to the tunica albuginea of the underlying corporal bodies (or a reapproximated dartos fascia if available for mobilization and coverage of the corpora) using 5-0 absorbable sutures. Additional sutures approximate the lateral graft to the skin edges in an interrupted fashion, and the graft is quilted to the tunica albuginea as well (Fig. 39.24A). A nonadherent bolster dressing is tied down to the base of the graft (Fig. 39.24B). If a wider residual urethral plate can be preserved, we split and lateralize the corpus spongiosum in a “first-stage Asopa” technique so that less oral mucosa is required (Fig. 39.25).

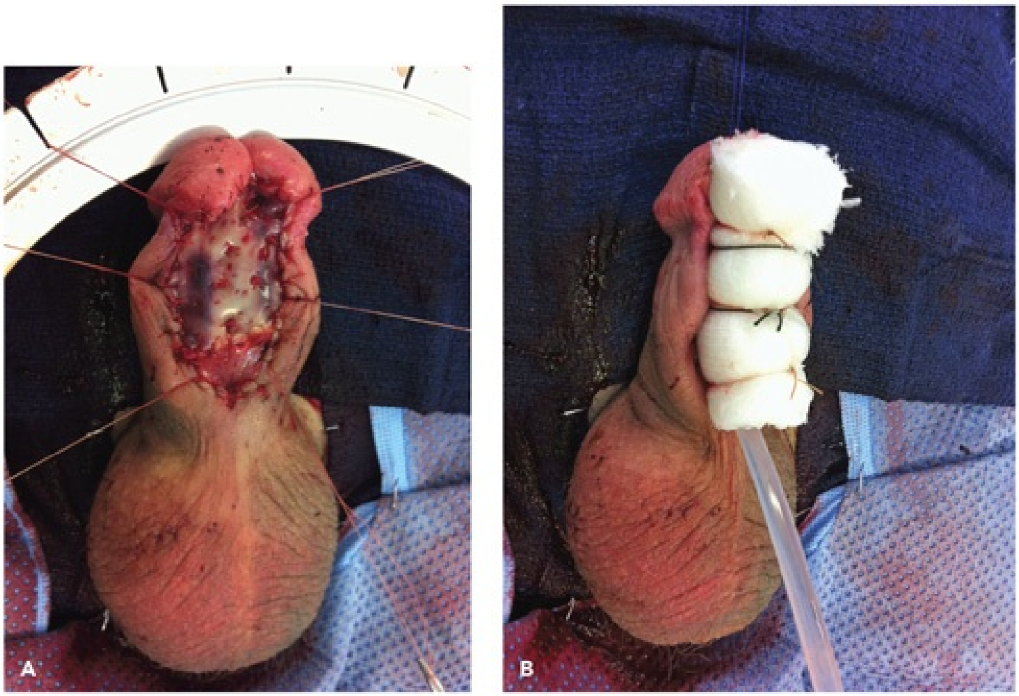


FIGURE 39.24 First-stage urethroplasty. **A:** After excision of entire distal penile urethra and meatus, a buccal graft has been spread fixed in place and anastomosed to the spatulated proximal urethrostomy. **B:** Bolster dressing secured with sutures.

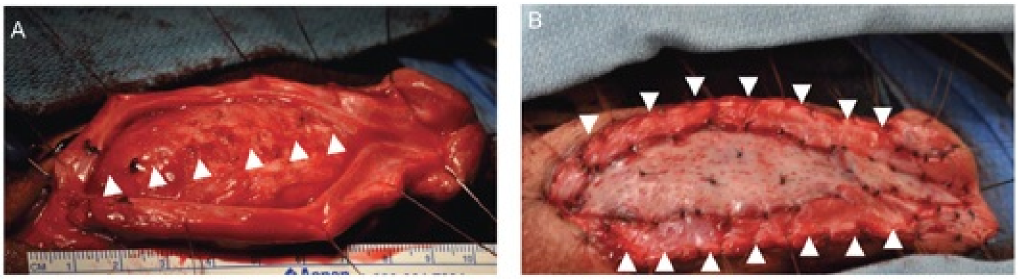


FIGURE 39.25 “Staged Asopa” technique. A long penile urethral stricture after mobilization of the entire corpus spongiosum and ventral urethrotomy. **A:** The urethral plate has been incised ventrally along its length as well as dorsally (*arrowheads* show tunica albuginea visible in defect). **B:** Buccal grafts have been secured in the midline and the urethral plate is fixed laterally (*arrowheads* show lateral margins of urethral plate between graft and skin). Technique described by McClung et al. at 2010 (55) Meeting of the American Urological Association.

Postoperatively, the graft is immobilized for 3 to 5 days, after which time the surgical bolster is removed. During the ensuing week, antibiotic-impregnated fine gauze provides protection and coverage of the grafts, and catheter drainage is continued for a total of 10 to 14 days. Once the urethral catheter is removed, daily application of a barrier emollient (e.g., Eucerin) keeps the skin protected and moisturized until second-stage closure.

Second Stage

The neourethral plate requires 6 to 9 months to gain neovascularization and adequate compliance before tubularization. Once adequate pliability and appearance has been achieved (Fig. 39.26), second-stage closure can be scheduled. Approximately 10% to 20% of cases will require revision for graft contracture, stenosis of the proximal urethrostomy, or other complications (54).

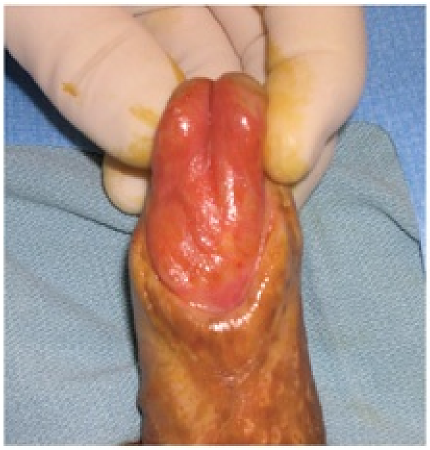


FIGURE 39.26 Appearance of urethra 9 months after first stage urethroplasty.

Adequate width of graft is mapped to tubularize the urethra (Fig. 39.27). The perimeter of the neourethra is incised and sharply elevated off of the tunica albuginea of the underlying corpora cavernosa, preserving any supporting tissue. Once adequate mobilization has been gained, a few holding sutures to reapproximate the edges over a 20Fr catheter confirm adequacy of the diameter (Fig. 39.28). The urethroplasty is closed with running or interrupted 5-0 polyglactin or polyglycolic acid sutures. Coverage with dartos flaps or tunica vaginalis is advisable along the penile urethra and at the subcoronal margin below the glans. The skin is closed in an interrupted fashion with an absorbable suture. The urethral catheter is removed 10 days after surgery. Cosmesis of the meatus may be outstanding if the etiology was iatrogenic or traumatic (Fig. 39.29). With hypospadias and lichen sclerosus, results may be less ideal.

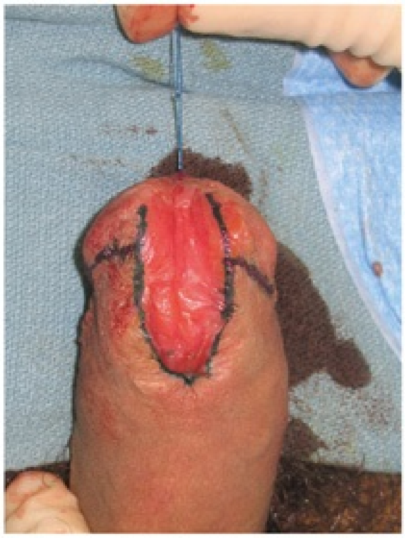


FIGURE 39.27 Second-stage urethroplasty: marked for tubularization.

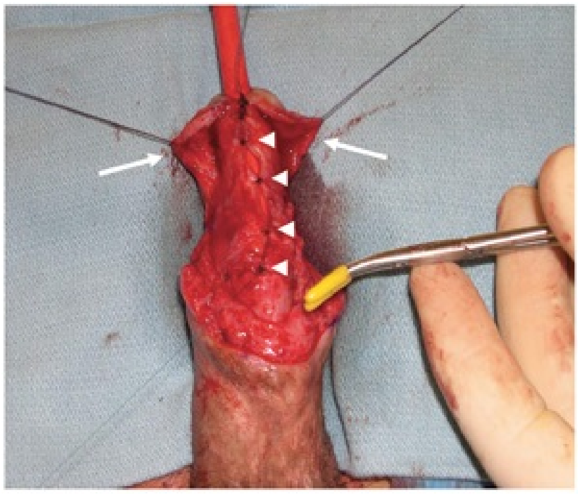


FIGURE 39.28 Second-stage urethroplasty: preliminary tubularization over a 24Fr catheter with holding stitches (*arrowheads*) and glans wings (*arrows*).

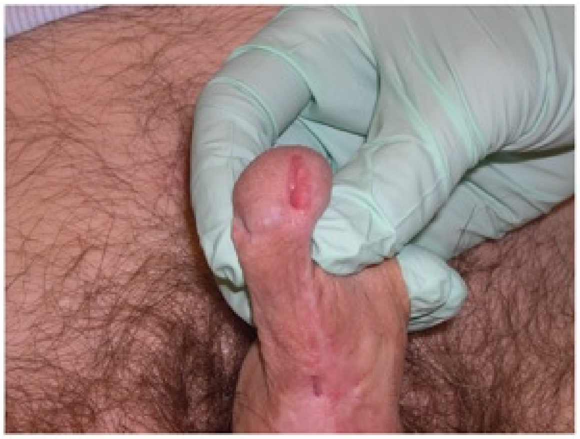


FIGURE 39.29 Second-stage urethroplasty: final cosmetic appearance of glans and meatus.

When the urethral plate does not easily tubularize over a large-bore catheter, adjunctive measures to achieve appropriate closure include incorporation of small skin flaps (Figs. 39.30 and 39.31) or free grafts. Failure to achieve tubularization due to more significant graft loss or fibrosis of adjacent tissues requires revision with placement of additional buccal grafts or meshed split-thickness skin (56,57), delaying closure for another 6 to 9 months.

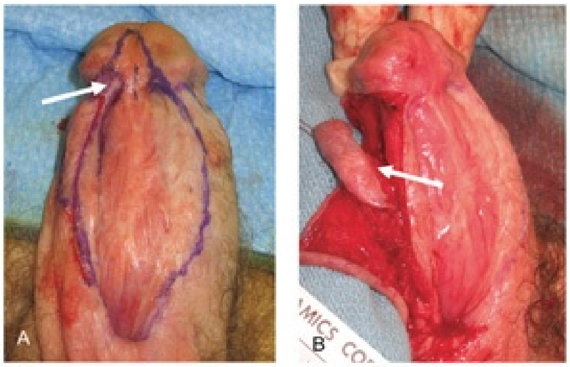


FIGURE 39.30 Planning of second-stage urethroplasty. **A:** Note insufficient tissue for closure at coronal margin, where lateral edges of the urethral plate are marked. **B:** Creation of longitudinal skin flap for additional ventral urethral substitution (*arrow*) based on dartos pedicle.

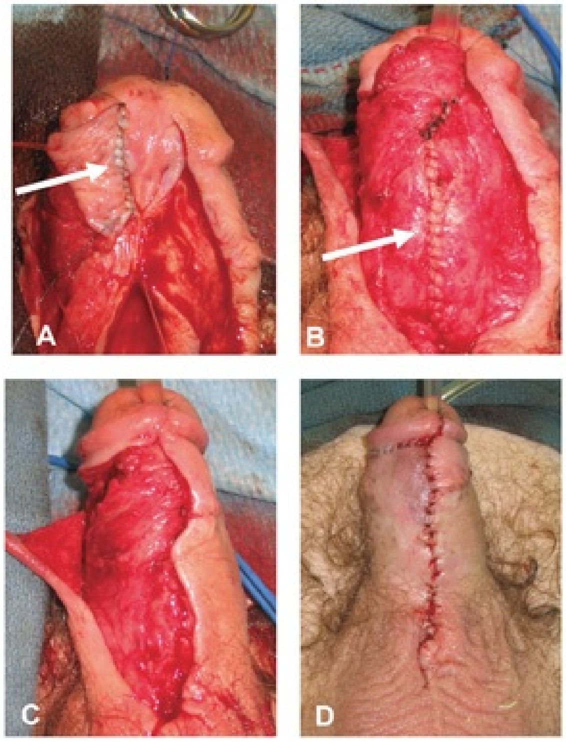


FIGURE 39.31 Second-stage urethroplasty closure. **A:** Anastomosis of skin flap to urethral plate at point of narrowing (*arrow*). **B:** Closure of entire neourethra (*arrow* on buccal graft tubularization suture line). **C:** Coverage of suture line by dartos. **D:** Skin closure.

Outcomes and Follow-up

We define success using a binary outcome based on the ability to pass a flexible 16Fr cystoscope across the reconstructed urethra, although no consensus method has been adopted consistently worldwide (6). Table 39.1 shows rates of stricture recurrence based on the experience of the author, along with our preferred protocol for follow-up by location and type of reconstruction. Surveillance for stricture recurrence varies from center to center; we verify patency at 3 and 12 months. Beyond this time point, recurrence rates decrease and patients are followed symptomatically.

Complications

Complications of urethroplasty relate to positioning, infection, donor site, fistula formation, sexual dysfunction, and stricture recurrence. Minor surgical complications include incisional bleeding, hematuria, and diverticulum formation, occurring in less than 5% of patients after substitution urethroplasty (8). Complications of the lithotomy position include neurapraxia, back pain, and rare compartmental syndrome of the calf. Careful postoperative assessment of the neurovascular integrity of the legs is key to early detection of any problems. Immediate orthopedic consultation is mandatory if compartmental syndrome is suspected.

Oral donor sites may undergo contraction and cause pain or minor difficulties with food or saliva. Fistula formation after staged urethroplasty occurs in 15% of second-stage closures (Fig. 39.32A) but can usually be closed primarily because of the widely patent urethral lumen (Fig. 39.32B). Sexual dysfunction may occur after urethroplasty, and therefore, assessment of baseline function prior to surgery is advisable. Although approximately 40% of men experience a degree of erectile dysfunction after urethroplasty, the majority return to baseline within 1 year (58,59). Orgasmic dysfunction, in particular abnormal ejaculation, is prevalent in men with urethral stricture disease and is likely to improve postoperatively (59).

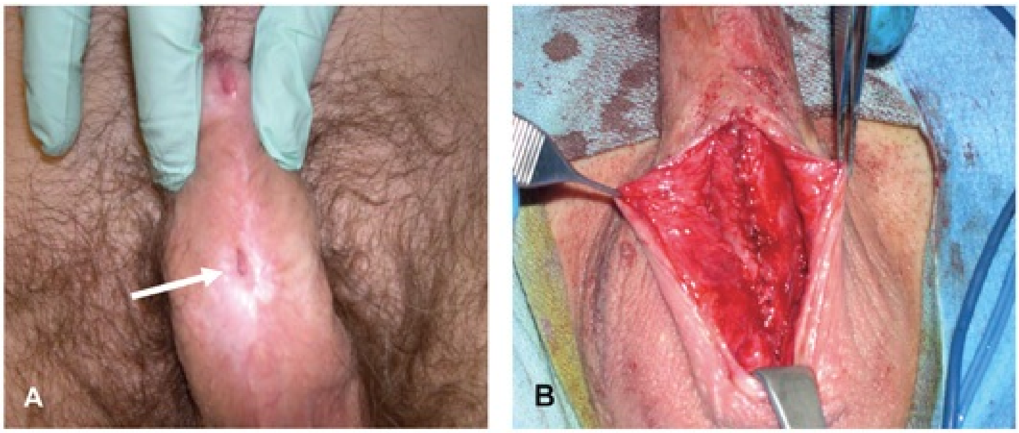


FIGURE 39.32 Urethrocutaneous fistula after second-stage urethroplasty. A: Fistula (*arrow*) at midshaft. B: Repair by primary closure.

Perspectives

The essence of reconstructive surgery transcends its technical armamentarium, consisting of a mind-set about how to approach a complex problem, break it down to a series of linked but independent steps, and apply appropriate and increasingly sophisticated techniques to achieve the end goal. The most complex strategies are used only as necessary. A key feature is the stepwise approach, remaining open-minded and flexible and never “burning bridges” until it is clear that lesser techniques are no longer applicable. Examples of this include selection of initial skin incisions that do not limit the subsequent ability to create a skin flap, the choice to transect or incise the urethral plate, considerations about mobilizing dartos or other flaps, and the ultimate decision whether to perform a procedure in one or a series of stages. Successful urethral reconstruction also requires the ability to recognize when one has done enough for a given surgery. A panurethral stricture may be approached in one stage all at once; but different local tissue characteristics, severity of the stricture, body habitus, and need for excision of portions of the strictures may dictate that the surgeon only work on the most severely affected part of the urethra, coming back another day to manage less severely affected portions with an alternative strategy. Reconstruction is best viewed as a continuum, which may require multiple operations, multiple techniques, and revision surgery to achieve successful outcomes.

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CHAPTER 40 SURGERY FOR URETHRAL TRAUMA INCLUDING URETHRAL DISRUPTION

TIMOTHY J. TAUSCH, JAY SIMHAN, AND ALLEN F. MOREY

Early recognition and diagnosis of urethral injuries are crucial to the successful management and prevention of long-term complications. Management of traumatic urethral injuries depends on the location of urethral stenosis. The urethra is divided into anterior (pendulous and bulbar urethra) and posterior (membranous and prostatic urethra) segments, with specific mechanisms of injury for either segment that will ultimately influence therapy and outcomes. Immediate management of anterior and posterior urethral trauma predominantly involves temporizing solutions to divert urine away from the urethral injury, although immediate surgical management of acute anterior urethral trauma may often be appropriate. Many patients with posterior injuries ultimately require formal surgical repair several months following the initial injury.

ANTERIOR URETHRAL INJURIES

The anterior urethra extends distally from the membranous urethra to the urethral meatus (Fig. 40.1). Contrary to the posterior urethra, the anterior urethra is encompassed by the corpus spongiosum, the deep (Buck) fascia, and the superficial (dartos) fascia along its entire length. The penoscrotal junction divides the shorter, proximal bulbar urethra from the longer, distal pendulous urethra. The bulbospongiosus muscle ventrally covers the bulbar urethra and terminates at the penoscrotal junction, prior to the origination of the distal pendulous urethra. The pendulous urethra closely approximates the corpora cavernosa during most of its length, with the lumen of the distal pendulous urethra dilating distally to form the fossa navicularis.

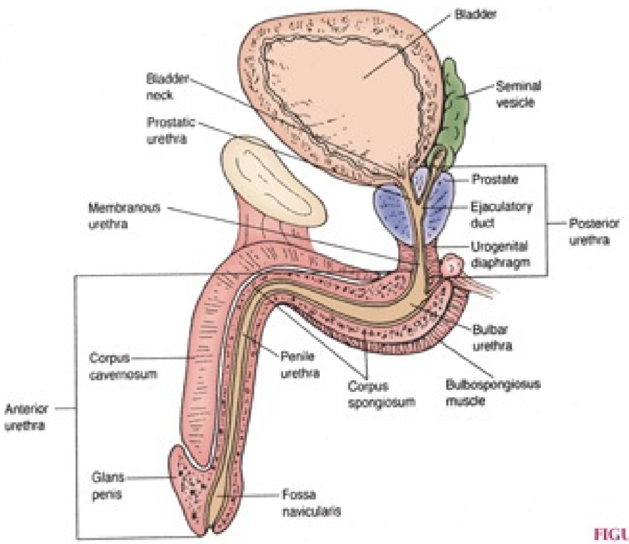

FIGURE 40.1 Anatomy of the anterior and posterior urethra.

Although susceptible to penetrating trauma (e.g., stab or gunshot wounds), injuries to the anterior urethra most commonly involve blunt compression (“straddle”) injuries, penile fracture with concomitant urethral disruption, iatrogenic trauma (e.g., after Foley catheterization or endoscopic urethral surgery), and constriction rings. Compression of the bulbar urethra against the pubic bone, or a “straddle injury,” is the most commonly encountered anterior urethral injury and occurs after a direct force to the perineum compresses the bulbar urethra against the pubic bone. Alternatively, penile constriction rings can damage the anterior urethra secondary to tissue ischemia, whereas Foley catheterization or endoscopic urethral surgery can damage the bulbar urethra, resulting in contusion or partial urethral disruption. The true extent of iatrogenic injuries, along with trauma from constriction rings, may not become evident until many years after the original event (1). Although rarely associated with pelvic fractures, anterior urethral injuries may be encountered in approximately 15% of penile fractures (2).

Diagnosis

A careful history and physical examination should raise suspicion for anterior urethral injury because these insults may arise immediately or after a substantial period of time. Straddle injuries often present in a delayed fashion with obstructive voiding symptoms and an idiopathic etiology. In a large series of 78 patients with straddle injuries, Park and McAninch (3) reported great variability in the time to presentation, with 40% of patients presenting to the emergency department in an acute setting and 60% of patients presenting 6 months to 10 years after the original injury. Hematuria, penile sleeve hematoma (injury confined to Buck fascia), difficulty voiding, and perineal “butterfly” hematoma (injury penetration of Buck fascia) are common presenting symptoms in the acute setting. In addition to a perineal butterfly hematoma, penetration of Buck fascia can allow the spread of urine and/or blood to the scrotum (dartos fascia), anterior abdominal wall (Colles fascia), and/or thighs (fascia lata).

All patients with a suspected anterior urethral injury should undergo a retrograde urethrogram prior to an attempt at urethral catheter placement. Ideally, the patient should be placed obliquely at a 30- to 45-degree angle with the bottom leg flexed at 90 degrees and the top leg kept straight (Fig. 40.2). In the acute setting, associated pelvic fracture may preclude this position; therefore, a supine retrograde urethrogram may be employed to determine whether the urethral lumen has been disrupted. Flexible cystoscopy may also be used to aid with the diagnosis of urethral trauma, although radiographic imaging is usually sufficient for a diagnosis of urethral trauma.

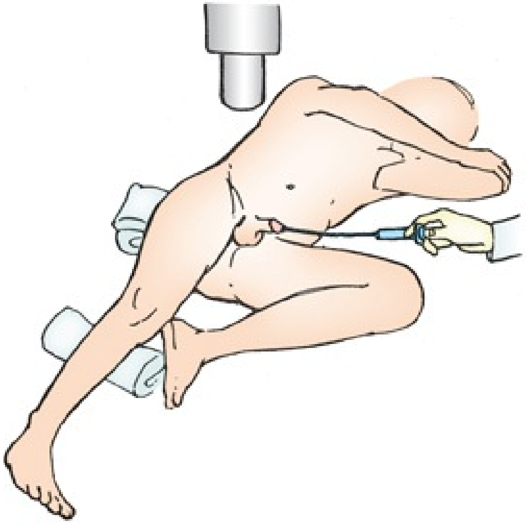

FIGURE 40.2 Proper positioning for retrograde urethrography. The patient is placed obliquely at a 45-degree angle with the bottom leg flexed and the top leg straight. Slight traction on the penis during injection of contrast helps avoid telescoping of the urethra and allows more accurate characterization of the injury.

The retrograde urethrogram should be performed with undiluted water-soluble contrast medium (full-strength [60%] ionic contrast medium). A scout film provides initial information on patient position, the potential presence of a foreign body, as well as any fractures to the bony structures of the pelvis. A 12Fr Foley catheter is then placed into the fossa navicularis, and the balloon is inflated with 3 mL of sterile water to prevent catheter dislodgment during the evaluation. The penis is positioned laterally on slight stretch to provide a more descriptive study, and 20 to 30 mL of contrast is then injected in a retrograde fashion. Dynamic fluoroscopy is ideal; however, in the setting of acute trauma in the emergency department, static radiographs will suffice. Although the anterior urethra can be visualized in its entirety during a retrograde urethrogram, the posterior urethra is typically excluded by reflex contraction of the external sphincter. If a catheter is present at the time of evaluation, a cystogram is recommended to confirm the catheter's presence in the bladder. After documenting the correct location of the urethral catheter, a pericatheter retrograde urethrogram may additionally be performed to delineate any possible urethral injury.

Anterior urethral injuries are classified into three groups based upon radiographic, clinical, or endoscopic findings. Although *contusions* may appear normal on retrograde urethrogram, these injuries are best determined with clinical suspicion through cystoscopy in the setting of a “normal” retrograde urethrogram. Alternatively, *partial disruptions* appear as extravasated urine on retrograde urethrogram with visualization of contrast in the urethra or bladder proximal to the injury. *Complete disruptions* appear as total extravasation without visualization of contrast in the more proximal urethra or bladder.

Indications for Surgery

Primary surgical repair of acute anterior urethral injuries is recommended in the context of penetrating injury. We also recommend an attempt at anterior urethral repair in the setting of penile fracture. Because these repairs are delicate and potentially time-consuming, any attempt at immediate repair is predicated on the stability of the patient. Injuries to the posterior urethra should be managed in a delayed fashion, without attempt at a formal urethroplasty in the acute setting. Posterior urethral injuries are discussed later in this chapter.

Alternative Therapy

Alternative options to surgical repair involve the temporary diversion of urine through the placement of a urethral or suprapubic catheter. Contusions to the anterior urethra should be managed with a urethral catheter for approximately 2 weeks followed by a voiding cystourethrogram to confirm urethral patency. The patient should be counseled on the possibility of delayed development of a urethral stricture at the site of contusion.

Partial urethral disruptions diagnosed by retrograde urethrogram may be managed via various algorithms. We prefer urinary diversion with formal repair after a minimum of 2 months to allow resolution of inflammation and maturation of scar tissue. Although some experts support one attempt at Foley catheter placement, the possibility of causing a complete urethral disruption during this attempt should be considered. If urethral placement is unsuccessful, percutaneous suprapubic tube placement should be performed. The preservation of urethral mucosa with partial disruptions may be adequate for re-epithelialization and eventual luminal recanalization; however, we would recommend periodic evaluation with uroflow studies and counseling patients regarding the possibility of future stricture development.

Surgical Technique

Open surgical repair is primarily reserved for stable patients after open or penetrating injury to the anterior urethra. The patient is placed in either the supine position or lithotomy position and draped widely to allow exploration of potential concomitant injuries to the penis, testes, perineum, and rectum. Clean wounds need only minimal debridement followed by urethral closure with interrupted or running 5-0 polyglyconate monofilament (polydioxanone) sutures over a 16Fr catheter. Contaminated wounds require thorough irrigation and debridement of devitalized tissues to ensure reapproximation of healthy tissue.

With open or penetrating bulbar urethra injuries, the patient is placed in the lithotomy position with adjustable stirrups, and a vertical perineal incision is performed along the raphe. As expected, only stable patients without injury precluding the lithotomy position should be offered acute surgical intervention. The urethra is exposed after division of Colles fascia and the bulbospongiosus muscle. A perineal retractor (e.g., perineal Bookwalter or Lone Star retractor, Cooper Surgical, Trumbull, Connecticut) is used to assist with perineal dissection. Surgeons should avoid acute repair of long bulbar urethral defects (>2 to 3 cm) because more complex intervention with grafts or flaps will be required. The most important factor promoting a successful outcome is the creation of a tension-free anastomosis; therefore, generous mobilization of the urethra is an important step to ensure adequate urethral length. Once adequate length is achieved, the urethral ends are spatulated (Fig. 40.3). The anastomosis is performed with interrupted 5-0 polyglyconate monofilament suture to create a tension-free, watertight closure. The dorsal surface is closed in one layer with 5-0 interrupted polyglyconate monofilament suture incorporating the urethral mucosa and spongiosal adventitia. Since the ventral bulbar urethra is vascularized by the spongy urethra, we advocate ventral spongiosum closure in two layers: the first, inner layer, closed with interrupted 5-0 polyglyconate monofilament suture and the second, outer layer, with a running 5-0 polyglyconate monofilament suture (Fig. 40.4). No further attempt is made to control bleeding from the spongy urethra during closure, as we believe that the added vascularity from the spongy urethra provides enhanced healing of the anastomosis. We also recommend that a first-stage marsupialization of healthy proximal urethra be considered if tension-free closure cannot be achieved or if there is significant wound inflammation or contamination.

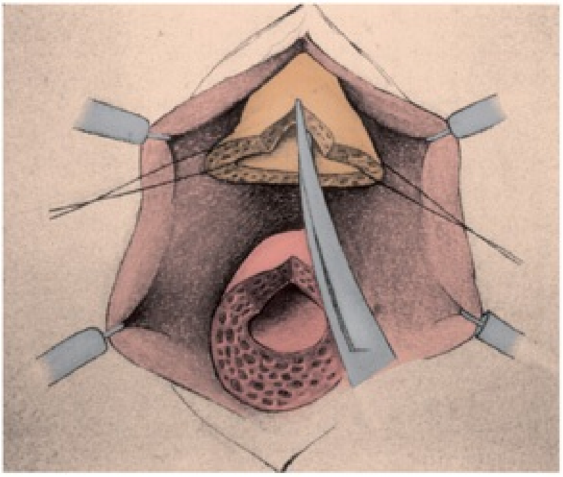

FIGURE 40.3 Repair of bulbar urethral injuries. The urethra is mobilized and spatulated in preparation for a tension-free end-to-end anastomosis.

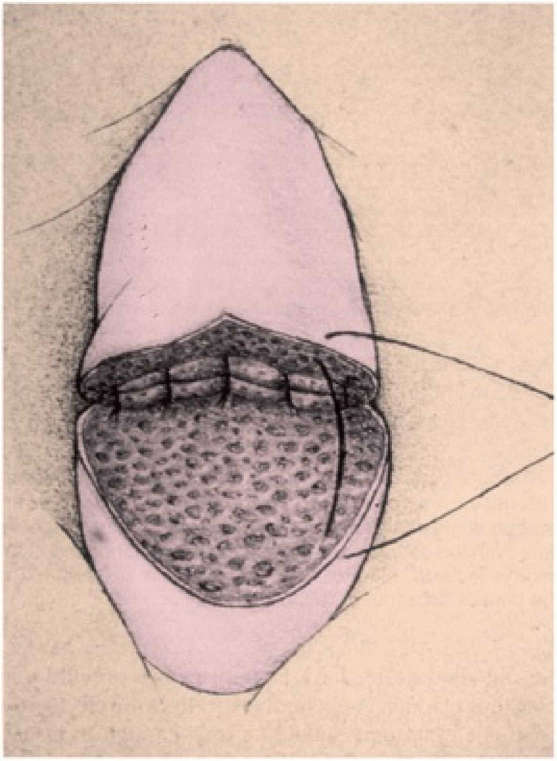

FIGURE 40.4 Repair of bulbar urethral injuries. Anastomosis is carried out with a single-layer dorsal closure and a two-layer ventral closure using interrupted 5-0 or 6-0 Maxon sutures.

For most penile urethral injuries, we prefer a longitudinal incision directly over the area of injury. Contrary to bulbar urethral injury, anastomotic repair should not be considered for defects >15 mm, as the risk of penile chordee is higher with penile anastomotic repairs. Instead, we prefer to use buccal mucosa in either an inlay, onlay, or combined approach. We routinely use 16Fr silicone Foley catheters at the time of urethral repair. Suppressive antibiotics are given while the catheter is in place to maintain urine sterility, with a voiding cystourethrogram performed after 2 to 3 weeks. If extravasation is noted, we gently replace the catheter for an additional period of time with repeat imaging at the time of urethral catheter removal.

Outcomes

Complications

The major complications relating to anterior urethral trauma include urethral stricture formation and infection. If untreated, persistent extravasation of infected urine or blood may lead to urethrocutaneous fistula, urethral abscess, or urethral diverticula. Prolonged urine extravasation into the corpus spongiosum may also lead to added spongiofibrosis, resulting in a longer urethral stricture. Consequently, a longer anterior urethral stricture translates to more complex management with a buccal mucosa graft or fasciocutaneous flap.

Patients with resultant urethral strictures are often subjected to endoscopic procedures such as dilations or urethrotomies that frequently need to be repeated. Such interventions can subject patients to pain and complications negatively impacting quality of life. Success of dilations is also low, with most patients eventually requiring definitive urethral repair.

With early urinary diversion, many anterior urethral strictures will never progress and remain amenable to excision. Incontinence and impotence, although common in posterior urethral injuries, are uncommon in anterior urethral injuries. Stricture recurrence is most common in the first 12 months, so close follow-up is required.

Results

Anastomotic urethroplasty can be performed successfully in a high percentage of patients who sustain a bulbar urethra (straddle) injury requiring surgery. The procedure has an overall success rate of approximately 95% when performed in a delayed setting (3). As mentioned previously, patients sustaining open or penetrating injuries associated with minimal inflammation are the best candidates for acute repair; otherwise, urinary diversion with suprapubic tube placement is recommended with formal repair at a later date.

POSTERIOR URETHRAL INJURIES

Posterior Urethral Anatomy

The urethra is divided into anterior and posterior anatomic segments by the urogenital perineal membrane. The posterior urethra consists of the membranous and prostatic urethra and is much shorter than the anterior urethra (Fig. 40.1). Extending from the bladder neck to the apex of the prostate, the prostatic urethra is secured to the pubic bone by the paired puboprostatic ligaments. During cystoscopy, the verumontanum marks the most distal aspect of the prostatic urethra. The bladder neck sphincter is an extension of smooth muscle fibers of the trigone and prostatic urethra cephalad to the verumontanum. The distal sphincter is approximately 2.5 cm long and consists of smooth muscle fibers caudad to the verumontanum, including the rhabdosphincter (slow-twitch skeletal muscle fibers) (4). The distal sphincter is only 3 to 4 mm thick and forms the entire thickness of the membranous urethra (5). In the absence of a functional distal urethral sphincter, the proximal urethral sphincter can maintain urinary continence in select patients; however, the bladder must be compliant and free from periodic elevations of detrusor pressure (e.g., detrusor overactivity).

Injury to the membranous urethra is not uncommon given its location between two relatively fixed points (prostate and bulbar urethra). Since the distal urethral sphincter is located in the membranous urethra, shear injuries leading to partial or complete membranous urethral disruption can result in distal urethral sphincter damage.

Injuries to the Posterior Urethra

Injuries to the posterior urethra are typically associated with major, often life-threatening, trauma, as a consequence of the significant blunt forces required to generate a pelvic fracture (e.g., intra-abdominal and vascular injuries to the pelvic vasculature). Posterior urethral trauma is almost always associated with pelvic fracture; conversely, only 10% to 15% of pelvic fractures are associated with urethral injury. Bladder injury has also been diagnosed in 10% to 20% of patients with pelvic fracture and urethral injury (6). Other etiologies include penetrating trauma and iatrogenic injuries secondary to endoscopic, open, or minimally invasive prostate surgery.

The clinical and surgical appearance of each form of posterior urethral injury may differ. Endoscopic or open prostate surgery is associated with continuity strictures and preservation of the distal external urinary sphincter. In contrast, pelvic fractures are associated with urethral disruptions of the membranous urethra. These injuries have been termed *pelvic fracture urethral injuries* (PFUIs). Interestingly, a report has found that 7 of 10 patients examined at autopsy had urethral disruption after pelvic fracture *distal* to the external urinary sphincter, disputing the historical view that these injuries occur at the interface of the fixed prostatic apex and the less supported membranous urethra (7). Additionally, urodynamic studies have demonstrated a functional rhabdosphincter at the prostatomembranous region in many patients after anastomotic posterior urethroplasty for PFUI (4).

Diagnosis

PFUIs are the most common presentations in the acute trauma setting. Given the strong association of more serious concomitant injuries with PFUI, the first goal is resuscitation of the patient. Suspicious findings after PFUI mirror those of anterior urethral injuries, namely, hematuria, blood at the meatus, perineal hematoma, and difficulty voiding. Additionally, a high-riding prostate on digital rectal exam and specific pelvic fractures are linked with PFUI, although these diagnostic clues are not uniformly present. The prostate can appear elevated in position on digital rectal exam due to displacement from a pelvic hematoma and/or digital confirmation of the prostate may be indistinguishable from the pelvic hematoma. Regarding pelvic fractures, displacement of the inferomedial pubic bone and pubic symphysis diastasis are independently associated with urethral injury (8).

In a patient with a suspected PFUI, a retrograde urethrogram should be performed prior to any attempt at catheter placement (Fig. 40.5). If normal, the catheter can be advanced into the bladder and a formal cystogram should be obtained to assess for bladder perforation. The technique for retrograde urethrogram was discussed previously. As part of a formal cystogram, three radiographic views should be obtained, including an anterior-posterior scout film, a full-bladder anterior-posterior film, and a drainage film. Passive filling to discomfort or 350 mL of contrast is recommended to avoid false-negative results. Other studies to further delineate posterior urethral injuries include flexible cystoscopy; however, we caution against advancing the cystoscope past the site of injury for fear of exacerbating the injury.

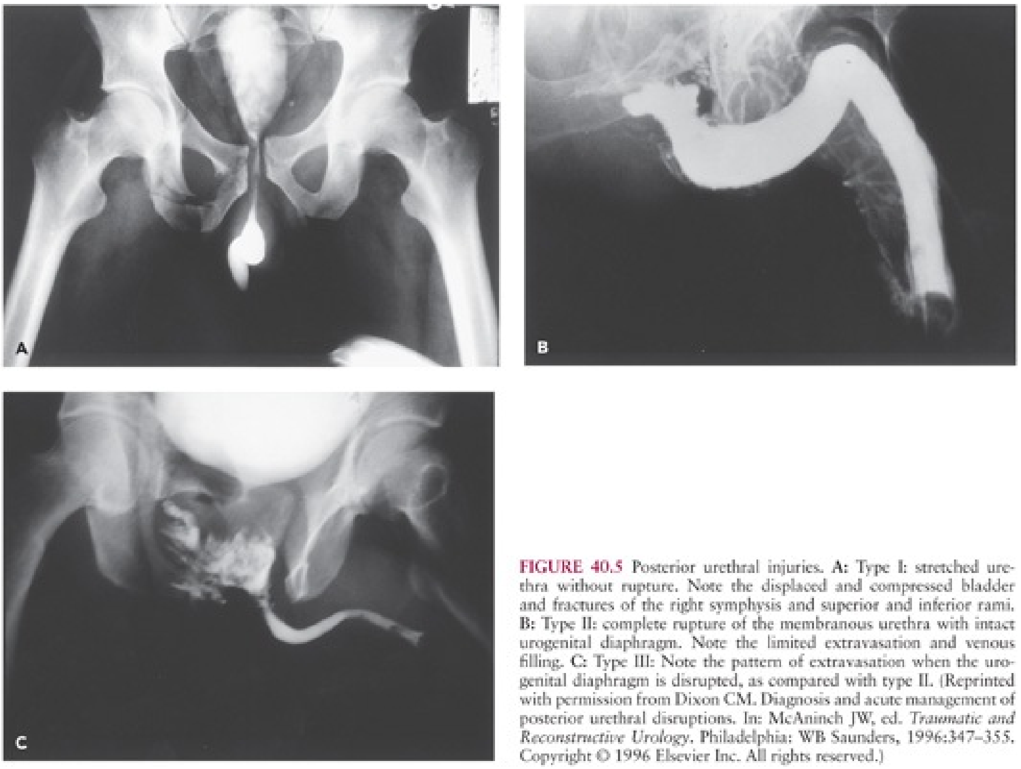

FIGURE 40.5 Posterior urethral injuries. **A:** Type I: stretched urethra without rupture. Note the displaced and compressed bladder and fractures of the right symphysis and superior and inferior rami. **B:** Type II: complete rupture of the membranous urethra with intact urogenital diaphragm. Note the limited extravasation and venous filling. **C:** Type III: Note the pattern of extravasation when the urogenital diaphragm is disrupted, as compared with type II. (Reprinted with permission from Dixon CM. Diagnosis and acute management of posterior urethral disruptions. In: McAninch JW, ed. *Traumatic and Reconstructive Urology*. Philadelphia: WB Saunders, 1996:347–355. Copyright © 1996 Elsevier Inc. All rights reserved.)

Posterior urethral injuries secondary to blunt trauma have historically been classified based on the Colapinto and McCallum system (9). A more recent modification maintains the original three classes of injury, revised system to include injuries that extend to the bladder neck and blunt anterior urethral injuries (Table 40.1) (10).

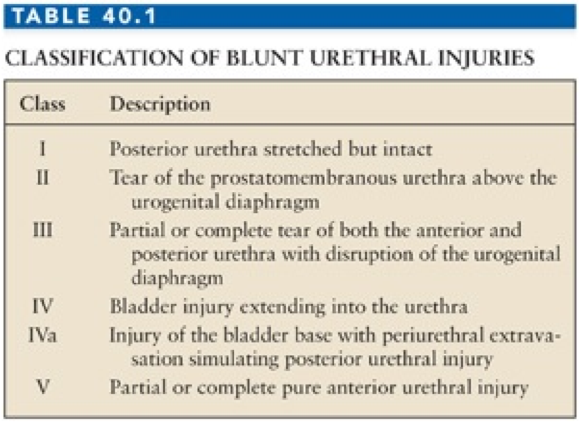

TABLE 40.1

CLASSIFICATION OF BLUNT URETHRAL INJURIES

Class	Description
I	Posterior urethra stretched but intact
II	Tear of the prostatomembranous urethra above the urogenital diaphragm
III	Partial or complete tear of both the anterior and posterior urethra with disruption of the urogenital diaphragm
IV	Bladder injury extending into the urethra
IVa	Injury of the bladder base with periurethral extravasation simulating posterior urethral injury
V	Partial or complete pure anterior urethral injury

Indications for Surgery

Debate continues regarding whether primary endoscopic realignment (PER) or suprapubic tube (SPT) diversion (with delayed urethroplasty) is better for acute management of PFUI. There is no consensus among experts, with varying literature regarding the impact of each on eventual incontinence, impotence, and urethral stricture rates (11–25). The obvious benefit of primary alignment is a potentially lower stricture rate of 56% versus the 97% stricture rate seen with suprapubic catheter placement (25); however, a more recent series reported that PER is only successful in 21% (4/19) of patients (22). Additionally, a recent report of a large series showed that strictures that form after realignment can be shorter and therefore potentially easier to treat when undergoing urethroplasty (20).

One can conclude that urethral strictures after endoscopic alignment may be shorter, offering the possibility of a less invasive option, such as internal urethrotomy in lieu of formal perineal urethroplasty. Despite claims that periodic office urethral dilations are trivial to the patient, we strongly disagree with this assertion and counsel the patient early for posterior urethroplasty to definitively treat the persistent stricture (Fig. 40.6).

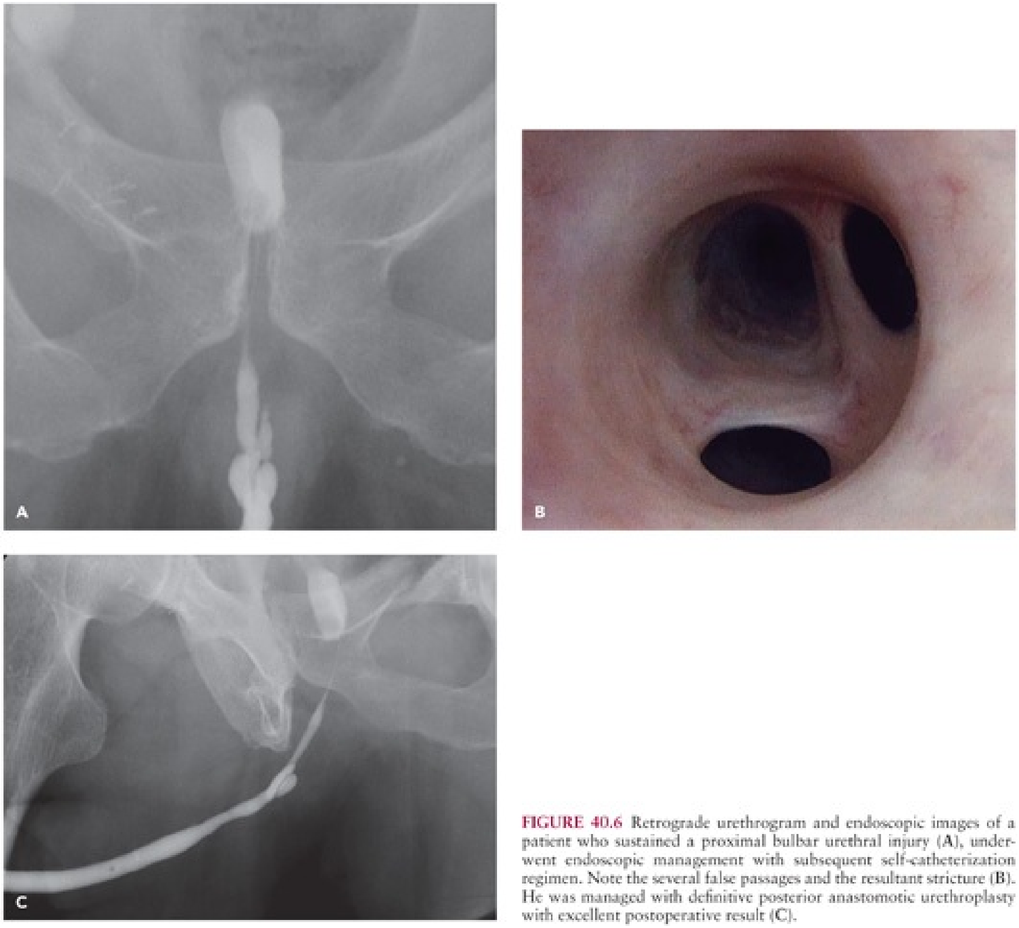

FIGURE 40.6 Retrograde urethrogram and endoscopic images of a patient who sustained a proximal bulbar urethral injury (A), underwent endoscopic management with subsequent self-catheterization regimen. Note the several false passages and the resultant stricture (B). He was managed with definitive posterior anastomotic urethroplasty with excellent postoperative result (C).

We would agree that PER and SPT placement are currently both acceptable for the acute management of PFUI. However, we prefer to manage these patients with SPT, with definitive and durable treatment via posterior urethroplasty 2 months postinjury. In the setting of a severely injured or unstable patient, one should perform percutaneous SPT placement as the more expeditious procedure.

Alternative Therapy

When concomitant bladder injuries occur, open suprapubic cystostomy allows for repair. If the patient is too unstable to allow operative exploration, then percutaneous SPT placement with or without ultrasound guidance is appropriate; however, percutaneous placement may be difficult if there is associated bladder injury. Therefore, open SPT placement can be performed after the patient is stabilized. Most bladder injuries associated with PFUI are extraperitoneal and heal spontaneously with catheter drainage; however, if surgical management of pelvic fractures is planned, operative repair of the associated bladder injury may reduce complication rates.

Primary suture repair of PFUI in the acute setting is associated with elevated impotence and incontinence rates. Primary suture repair of PFUI is not recommended for this reason, and also because of the more important risk of hemorrhage and contamination associated with evacuation of the retropubic hematoma to gain access to the injury site. The only clinical scenario in which we favor acute repair of PFUI is in the setting of concomitant extravasation at the bladder neck. We also recommend repair of rectal and vaginal lacerations in this clinical scenario.

Surgical Technique

Open Suprapubic Catheter Placement

For open suprapubic catheter placement, the patient is placed in the supine position. An infraumbilical incision is made to allow access to the prevesical space anterior to the bladder dome. After placing stay sutures around the anticipated cystostomy site, the bladder is opened vertically at the bladder dome, which will provide ample exposure to examine the bladder and urethra for injury. *Strict avoidance* of dissection into the space of Retzius and lateral perivesical space is essential to prevent pelvic hemorrhage and contamination. Therefore, in the presence of an associated bladder neck or bladder base injury, intravesical repair is recommended. An additional benefit of bladder neck repair is that it prevents the laceration from extending into the external urethra sphincter complex.

Bladder lacerations, if present, should be repaired in two layers with absorbable suture incorporating the detrusor muscle and a superficial absorbable suture incorporating the bladder mucosa. Open suprapubic catheter placement is performed in the bladder dome, and the bladder cystostomy site is fixed in place with a purse-string suture (Fig. 40.7). We do not favor Malecot catheters, as they have a higher propensity to be accidentally dislodged. Instead, we utilize a 20Fr to 24Fr Foley catheter with an inflation balloon. The vesicostomy is closed in two layers with 2-0 polyglactin suture. Regarding associated pelvic fractures, we recommend communicating with the orthopedic service to ensure that the SPT skin site does not interfere with future orthopedic operative endeavors. We do not use abdominal drains unless an associated bowel injury is present.

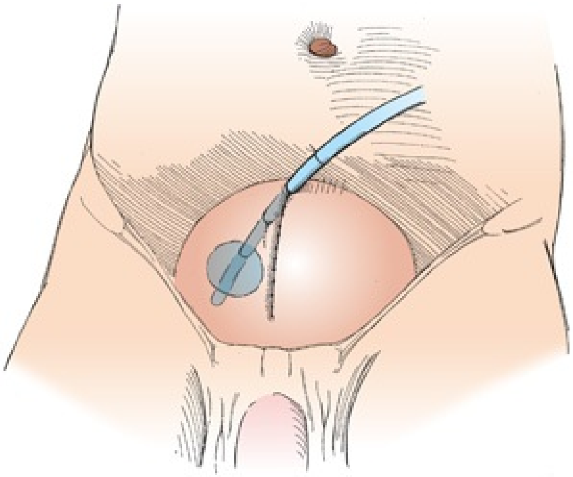

FIGURE 40.7 A large-caliber Foley catheter is placed in the bladder dome after inspection for concomitant bladder laceration. With the catheter placed through the superior end of the midline incision, bladder neck identification is facilitated at the time of subsequent reconstruction.

Delayed Posterior Urethroplasty

The principles of anastomotic urethroplasty are followed for repair of posterior urethral defects. These include epithelial apposition, establishment and/or preservation of blood supply to the anastomosis, resection of scar providing healthy tissue to hold sutures, and preservation of bladder neck competence. Our technique involves a midline perineal incision. Usually, the end result of a PFUI is a relatively short bulbomembranous gap, amenable to a straightforward primary anastomosis. We use 5-0 polydioxanone sutures on RB-1 needles in a 12-suture, “clock-face” configuration. Double-armed sutures are beneficial in ensuring mucosal edges are incorporated while also allowing for the knots to be tied on the extraluminal side of the urethra.

In rare cases of high prostatic dislocation, longer defects of >2 to 3 cm may result. For these cases, various maneuvers have traditionally been employed. Although a stepwise approach described by Webster and Ramon has been established (26), we have found that corporal splitting is rarely necessary, and the vasculature in that area can be spared providing better support of the anastomosis. Aggressive distal urethral mobilization nearly always yields enough length to achieve a tension-free anastomosis, and in severe cases, an inferior pubectomy can shorten the distance in order to complete the repair (27).

Outcomes

Complications

Complications after treatment of posterior urethral trauma are directly related to the severity of injury. Acute complications include pelvic hemorrhage and infection or abscess of the pelvic hematoma, which can occur after ill-advised retropubic exploration or attempts at pelvic hematoma evacuation. Delayed complications include incontinence, impotence, and urethral stricture formation.

Impotence and incontinence outcomes in the literature can be difficult to compare, with multiple reports claiming different results after endoscopic alignment and SPT with delayed urethroplasty. Sexual dysfunction is commonly associated with pelvic fracture, even in the absence of urethral injury (28). Management appears to affect postinjury erectile function and continence, with significantly better results with SPT and delayed urethroplasty compared to attempts at realignment. Realignment results in impotence rates as high as 44% and incontinence rates 20%, compared to delayed repair rates of 11.6% and 1.7%, respectively (29). Delayed return of potency has been reported after definitive urethroplasty; however, this would depend upon the severity of the initial injury (30).

Results

At our institution, delayed urethroplasty after SPT is the preferred management algorithm for PFUI. Posterior urethroplasty has been successful for resolution of stricture in 100% of patients initially managed by SPT and in 88% of patients who presented with strictures following attempts at PER. Stricture length was similar between these two groups (2.6 versus 2.8 cm, respectively); however, those patients undergoing attempts at PER had a significantly longer time course to durable resolution (7 versus 129 months, respectively). PER patients also experienced a mean of six endoscopic interventions prior to definitively urethroplasty. Endoscopic realignment may be an appropriate management strategy in the acute setting; however, urologists should carefully consider the better and timelier outcomes of SPT placement and referral for definitive posterior urethroplasty.

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CHAPTER 41 ■ CARCINOMA OF THE URETHRA (MALE AND FEMALE)

EUGENE J. PIETZAK AND THOMAS J. GUZZO

Primary urethral cancer is a rare tumor that accounts for less than 0.5% of all malignancies and only 1% of all genitourinary malignancies (1). Given the rarity of the disease, there exist no randomized controlled trials to guide management. Furthermore, the majority of literature on urethral cancer comes from retrospective analysis from single centers with cases spanning several decades. Many recommendations for treatment are based on general oncologic principles and extrapolation from other diseases.

Urethral cancer is also a heterogenous disease. There are various histologic subtypes including urothelial cell carcinoma (UCC) (54% to 65%), squamous cell carcinoma (SCC) (16% to 22%), adenocarcinoma carcinoma (10% to 16%), as well as a very small number of other tumor types (i.e., melanoma, clear cell carcinoma, sarcoma, etc.) (1). SCC was historically thought to be the most common subtype of urethral carcinoma, but data from both the European RARECARE project and Surveillance, Epidemiology, and End Results (SEER) have found UCC to be the most common (2,3). UCC of the urethra represents a “field defect” within the lower urinary tract, which mandates an evaluation of the upper urinary tract and consideration of excision of the bladder along with the entire urethra. Although histologic subtype has not been shown to affect outcomes, prognosis and treatment options do vary with the location and stage of the tumor (1). Distal tumors have a more favorable prognosis than proximal tumors in both men and women. Local control has been linked to improved cancer-specific survival; therefore, effective treatment of the primary tumor to reduce locoregional recurrence is of the utmost importance (4).

Historically, urethral cancer was once thought to be the only genitourinary cancer more common in females than males, but this was based on single center experiences (5). More recent data contradicts those findings and suggests the male-to-female ratio for urethral cancer is nearly 3:1 (2,3). Urethral carcinomas in men and women differ in several important aspects, including treatment, and therefore are discussed in separate sections of this chapter.

URETHRAL CARCINOMA IN MEN

Epidemiology, Risk Factors, and Presentation

The rate of urethral carcinoma is 4.3 cases per million for men, and only 1.5 cases per million in women according to an analysis of SEER data (3). The peak incidence of urethral carcinoma is between 75 and 84 years of age (3). Urethral cancer is exceedingly rare in those younger than 55 years old.

In men, urethral carcinoma is associated with several risk factors. Most common is a history of urethral stricture disease, which is present in over 50% of men with urethral cancer (1). Furthermore, over 25% have a history of sexually transmitted diseases (1). There is likely a causal relationship with human papillomavirus (HPV) 16 (1). Chronic urethritis and radiation exposure have also been implicated in urethral carcinoma development (1).

Nearly all patients with urethral carcinoma present with symptoms. The most common symptoms in men include hematuria/urethral bleeding, obstructive voiding symptoms, and a palpable mass. A high incidence of suspicion is required to reduce the delay to diagnosis.

Diagnosis and Staging

Physical examination of a patient with suspected urethral cancer should include inspection of urethral meatus with palpation of the entire urethra, looking for induration and fixation. Digital rectal examination and bimanual examination should be performed to determine the extent of tumor involvement. If needed, this can be done under anesthesia at time of cystoscopy with biopsies.

Tumor-node-metastasis system is the preferred staging system (Table 41.1), as prognosis is directly correlated with depth of tumor invasion, as well as nodal and distant metastatic involvement. In general, lymphatic drainage for distal tumors is to the superficial and deep inguinal lymph nodes, whereas proximal tumors drain to pelvic nodes. Because 20% to 30% of patients have nodal involvement at presentation, palpation of the bilateral inguinal lymph nodes must be done.

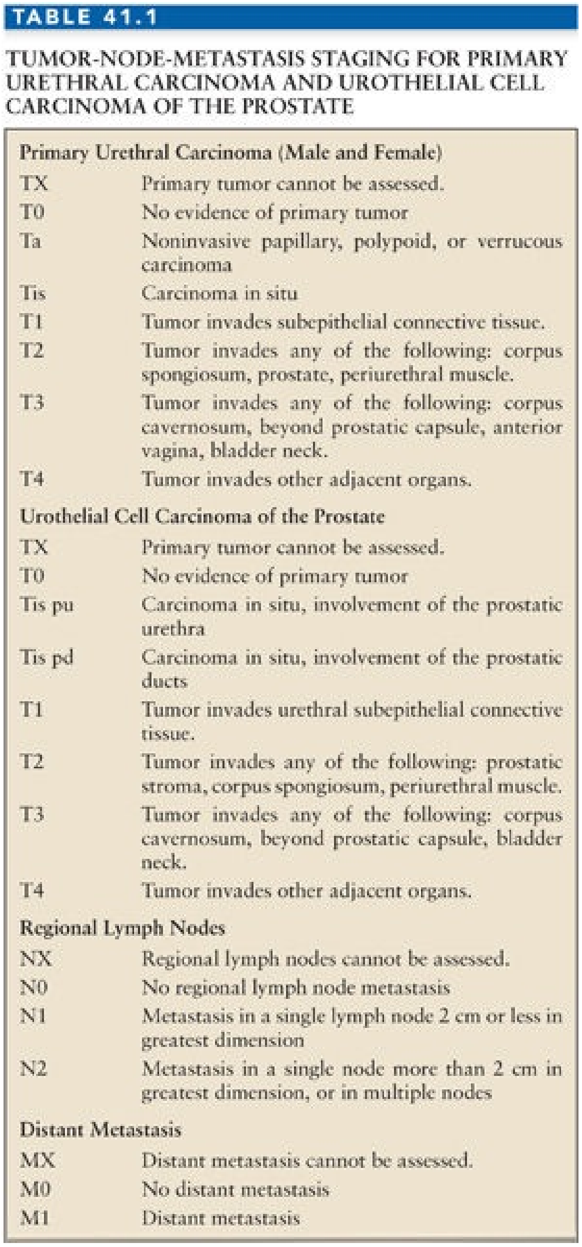

TABLE 41.1

TUMOR-NODE-METASTASIS STAGING FOR PRIMARY URETHRAL CARCINOMA AND UROTHELIAL CELL CARCINOMA OF THE PROSTATE

Primary Urethral Carcinoma (Male and Female)	
TX	Primary tumor cannot be assessed.
T0	No evidence of primary tumor
Ta	Noninvasive papillary, polypoid, or verrucous carcinoma
Tis	Carcinoma in situ
T1	Tumor invades subepithelial connective tissue.
T2	Tumor invades any of the following: corpus spongiosum, prostate, periurethral muscle.
T3	Tumor invades any of the following: corpus cavernosum, beyond prostatic capsule, anterior vagina, bladder neck.
T4	Tumor invades other adjacent organs.
Urothelial Cell Carcinoma of the Prostate	
TX	Primary tumor cannot be assessed.
T0	No evidence of primary tumor
Tis pu	Carcinoma in situ, involvement of the prostatic urethra
Tis pd	Carcinoma in situ, involvement of the prostatic ducts
T1	Tumor invades urethral subepithelial connective tissue.
T2	Tumor invades any of the following: prostatic stroma, corpus spongiosum, periurethral muscle.
T3	Tumor invades any of the following: corpus cavernosum, beyond prostatic capsule, bladder neck.
T4	Tumor invades other adjacent organs.
Regional Lymph Nodes	
NX	Regional lymph nodes cannot be assessed.
N0	No regional lymph node metastasis
N1	Metastasis in a single lymph node 2 cm or less in greatest dimension
N2	Metastasis in a single node more than 2 cm in greatest dimension, or in multiple nodes
Distant Metastasis	
MX	Distant metastasis cannot be assessed.
M0	No distant metastasis
M1	Distant metastasis

Cystourethroscopy should be performed to assess tumor extent and location. Cold-cup biopsies or transurethral resection should be performed to determine tumor histology. Biopsies distal and proximal to the tumor can provide useful information if organ-sparing surgery is considered. Complete cystoscopic examination should be done to rule out concomitant bladder tumors.

Radiographic imaging is obtained with the goal to accurately determine local tumor involvement and the presence of metastasis in lymph nodes and distant sites. Magnetic resonance imaging (MRI) is superior to computerized tomography (CT) scan regarding determining the extent of local tumor involvement including corpora cavernosa invasion (6). Either MRI or CT scan can be used for assessing regional metastasis in inguinal and pelvic lymph nodes. CT of the chest and abdomen is preferred for patients with invasive tumors to identify distant metastasis. In the absence of nodal involvement, a chest X-ray is likely adequate. Imaging of the upper urinary tract should be obtained for patients with urethral UCC to rule out any additional urothelial lesions.

Anatomy and Histopathology

The male urethra is approximately 22 cm long. The bulbar urethra should be considered part of the proximal segment with the prostatic and membranous urethra because treatment and prognosis is similar. Distal urethral tumors are those occurring in the penile urethra, fossa navicularis, and urethral meatus. Distal tumors have a superior survival rate to proximal tumors and distal tumors and may be more amenable to organ-sparing procedures (1). The difference in survival is thought to be from earlier detection of distal lesions that tend to present with symptoms at smaller size due to the narrower caliber lumen and the ease of self-palpation for the distal urethra.

The prostatic and bulbomembranous urethra are lined with urothelial cells, whereas the penile urethra is lined with pseudostratified columnar epithelium, and the meatus is lined with stratified squamous epithelium.

The proportions of histologic subtypes vary with location. Tumors within the prostatic urethra are almost exclusive UCC, with only 10% of prostatic urethral tumors being SCC, likely from squamous metaplasia in setting of chronic inflammation. Tumors of the bulbomembranous urethra are 80% SCC, 10% UCC, and 10% adenocarcinoma. For the penile urethra, 90% of tumors are SCC and 10% are UCC (7).

Urothelial Carcinoma of the Prostate

Urothelial carcinoma of the prostate represents a separate disease, which is reflected in the fact that there is a unique T staging for UCC of the prostate (Table 41.1). Cases of noninvasive UCC and urothelial carcinoma in situ (CIS) can be managed with a urethra-sparing approach with extensive transurethral resection (TUR) and subsequent bacille Calmette-Guérin (BCG) therapy (1). The addition of TUR with BCG improves freedom from urethral recurrence from 65.7% to 95.3% at median follow-up of 52 months; however, similar rates of overall recurrence are seen when bladder recurrence is considered (8). If prostatic urethra UCC is refractory to conservative treatment, or if stromal invasion is present, then radical cystoprostatectomy with pelvic lymphadenopathy should be performed. Neoadjuvant chemotherapy with methotrexate, vinblastine, doxorubicin, and cisplatin (MVAC) may be beneficial particularly if the tumor is locally advanced.

Concomitant urethrectomy at time of cystoprostatectomy for prostatic urethral carcinoma is controversial. Local recurrence within the urethra occurs in between 0.5% and 11.1% of patients with bladder cancer after cystoprostatectomy (7), and UCC of the prostatic urethra increases this risk. Some authors have argued, however, that provided the distal urethral margin is normal at the time of cystoprostatectomy, urethrectomy is not immediately indicated. If the urethra is left in situ, the surveillance after cystectomy is also highly contentious. A complete discussion of this topic is beyond the scope of this chapter.

Alternative Treatments

The primary treatment for urethral carcinoma in men is surgical excision; however, many men may potentially benefit from multimodal therapy. Given the rarity of urethral carcinoma, the optimal treatment paradigm has yet to be established, and patients with urethral carcinoma should be discussed in multidisciplinary team meetings, which involve the participation of urologic oncologists, medical oncologists, radiation oncologists, radiologists, and pathologists. In many situations, management of urethral carcinoma is extrapolated from experiences with other more common tumors (i.e., urethral

UCC with bladder UCC and urethral SCC with anal SCC).

Radiation monotherapy can be used in men who refuse surgery with early-stage distal tumors. Although radiation can be penile-sparing in these select patients, common side effects include skin ulceration, necrosis, and urethral strictures (7). Little is known of the long-term outcomes of this approach, but the risk of new tumor occurrence is present. Radiation is often used as part of multimodal approach for advanced disease in the neoadjuvant and adjuvant setting.

Given the rarity of urethral cancer, little is known regarding the role for adjuvant and neoadjuvant chemotherapy. No consensus exists for the particular regimen, but often, cisplatin, bleomycin, and methotrexate or radiosensitizing 5-fluorouracil and mitomycin C is used for SCC urethral tumors, and MVAC is used for urethral UCC (7).

Case series using definitive chemoradiation have also been reported for advanced urethral carcinoma. The most impressive results come from a series using 5-fluorouracil and mitomycin C with 45 to 55 Gy to the pelvis with a 12 to 15 Gy boost for gross disease. For a group with considerably advanced disease, the outcomes of this series were excellent with a 5-year cancer-specific survival rate of 72% when surgery was used for salvage purposes (9).

Surgical Treatment of Distal Tumors of the Male Urethra

The aggressive nature of urethral carcinoma and the frequent delay in diagnosis results in many patients with advanced disease at the time of initial presentation. Radical surgery is often required for local control. Surgery alone will not be curative in many with advanced disease, which underscores the need for multidisciplinary care.

Compared to proximal lesions, distal tumors have a far more favorable prognosis (10). Organ preservation may be possible in highly selected cases of early-stage tumors in the distal urethra. The objective of penile-sparing surgery is functional preservation (ability to void standing, maintenance of erectile function with adequate length for penetration) and acceptable cosmesis without compromising cancer control. Penile preservation is certainly not appropriate for all cases of urethral carcinoma.

If penile-sparing surgery is considered, accurate staging is even more vital, and an MRI is recommended to ensure corpora cavernosal invasion is not present. If corpora invasion is present, then standard treatment is partial or total penectomy with at least a 2-cm margin. Some authors have suggested a margin of only 5 mm may be adequate for local control, but these results from small case series must be interpreted with caution (1,11). Both partial and total penectomy are described in other chapters in this book.

For penile preservation, urethrectomy is the preferred technique, but local control can be attempted with endoscopic ablation for poor surgical candidates or patients who refuse surgery. As previously described by Zeidman et al. (12), TUR of urethral carcinoma is best performed with an initial cold-cup biopsy followed by complete resection of the tumor on cutting current. Aggressive resection is often preferred; so the catheter is left in place for several days, often with a pericatheter retrograde urethrogram prior to removal. Elective management of small-volume, low-grade tumors can be done with TUR or laser ablation, but the data available with this approach is limited.

Penile-Preserving Anterior Urethrectomy with Perineal Urethrostomy (Fig. 41.1)

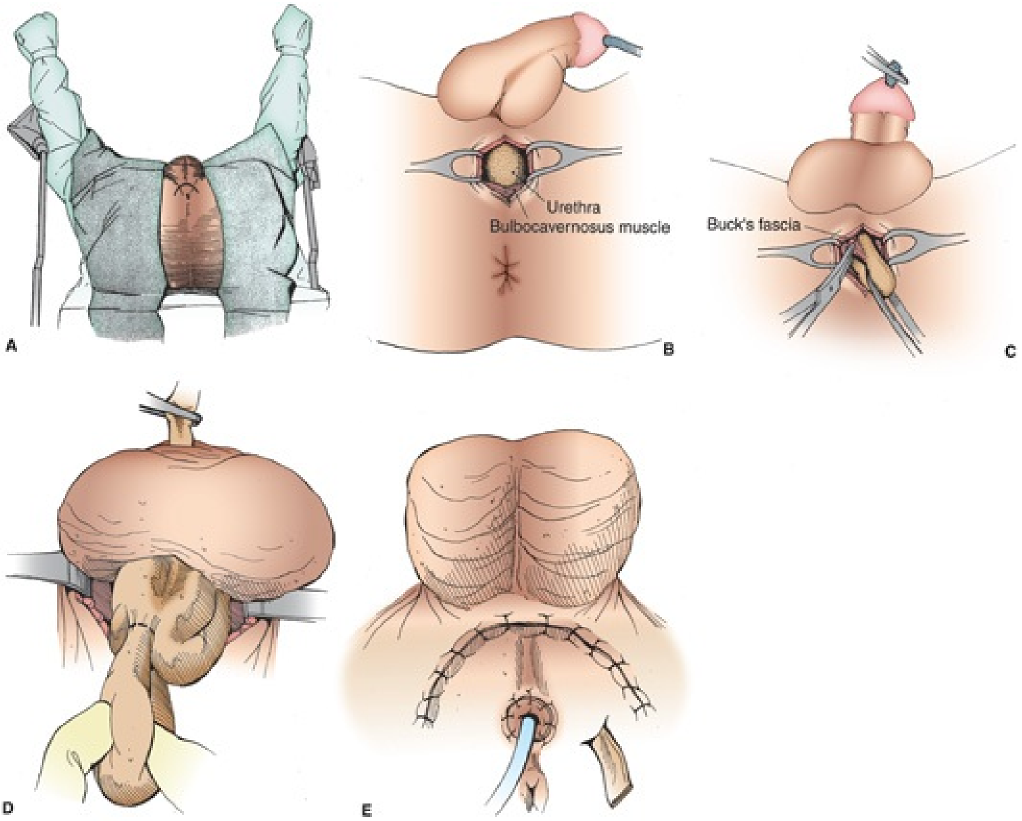

FIGURE 41.1 Technique of Anterior Urethrectomy with Perineal Urethrostomy

Urethrectomy with perineal urethrostomy is appropriate for select patients with tumor confined to the corpora spongiosum for whom a negative margin is achieved in the proximal urethra. Accurate staging with MRI should be done to ensure the absence of corpora invasion.

The patient is positioned in high dorsal lithotomy in “candy cane” stirrups with the hips rocked backward by a sacral bump (a beanbag and Gel-foam pad). Careful attention must be made to adequately pad all pressure points. A 16Fr Foley catheter is used to facilitate dissection of the urethra from the corporal bodies. Tacking stitches may be placed within the scrotal skin on both sides to facilitate exposure of the perineum.

A vertical midline perineal incision is made just below the scrotum and carried downward approximately 5 cm. Alternatively, an inverted U incision can be made with the apex of incision in the midperineum. Dissection using electrocautery is performed through the superficial fascia and fatty tissue until the bulbospongiosus muscle is identified. We prefer a Lone Star ring retractor system be used to facilitate exposure of the bulbar urethra. Using Metzenbaum scissors, the bulbospongiosus muscle is divided to exposure the bulbar urethra. Dissection of the bulbar urethra is continued on both sides using sharp dissection until the urethra is detached from the corpus cavernosum circumferentially. It is during this part of the dissection that the Foley catheter is most helpful in developing the plane between the corpus spongiosum and corpus cavernosum. A Penrose drain can be passed around the urethra and used as a “handle” as the dissection is carried distally to separate the urethra from the corpora. The penis will need to be progressively invaginated into the perineal incision to reach the distal aspects of the resection. As mobilization of the urethra continues distally, it is common for the plane between the urethral spongiosum and corpora to be lost near the fossa navicularis. At this point, the penis is then everted to its regular position and attention is turned to the urethral meatus.

Using a scalpel, an inverted T-shaped incision is made over the glandular urethra (Fig. 41.2). The remaining urethra with a small cuff of glandular tissue is resected until the entire length of the anterior urethra is freed. The urethra is then maneuvered into the perineal incision and amputated at least 2 cm proximal to the tumor. Frozen-section analysis must be performed to confirm that the proximal margin is free of disease. Further resection of the proximal urethra may be needed to ensure a negative margin.

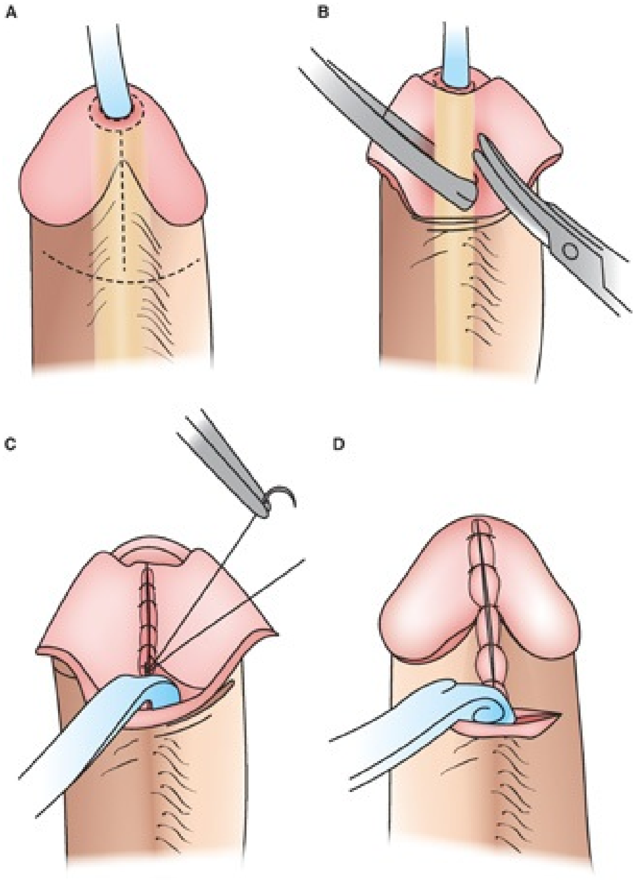

FIGURE 41.2 Distal dissection for urethrectomy.

Attention is then directed to the creation of a perineal urethrostomy. The proximal urethral stump is generously spatulated on its ventral aspect for at least a distance of 1 cm and then sutured to the perineal skin with interrupted 3-0 absorbable suture near the anastomotic apex. The remainder of the urethrocutaneous anastomosis is matured with the placement of equally spaced interrupted 4-0 absorbable sutures. To better preserve the blood supply to the corpus spongiosum, instead of taking full-thickness urethral bites, only the urethral mucosal edge and the adventitial edge are sutured together with the skin edge (13). Because the urethrostomy has a tendency to contract, the opening should be at least 30Fr. After the urethrocutaneous anastomosis is matured, a 20Fr or 22Fr Foley catheter is inserted into the bladder.

The perineal incision is closed in multiple layers with a perineal Penrose drain exiting from a separate stab incision. The Foley catheter is left in place for 7 to 10 days. The urethrostomy is monitored for signs and symptoms suggestive of stenotic changes such as urinary tract infections (UTIs), a low urinary flow rate, or a high postvoid residual urine volume.

Urethral Cancer Recurrence after Radical Cystectomy

Approximately 5% to 10% of patients after radical cystectomy will develop a subsequent urethral recurrence. A similar technique to anterior urethrectomy is used for a total completion urethrectomy for these patients with a history of bladder cancer who develop urethral cancer recurrence after treatment with radical cystoprostatectomy. The anterior urethra is completely mobilized from the corpora cavernosa as previously described; however, instead of creation of a perineal urethrostomy, the urethra is dissected proximally to the level of the urogenital diaphragm. The urethral hiatus within the diaphragm will need to be enlarged carefully to ensure the entire urethra is excised en bloc without injury to nearby neurovascular bundle (if nerve sparing was achieved at time of cystectomy).

Cautious dissection must also be performed because bowel is frequently present just superior to the urogenital diaphragm, and adhesions are not uncommon following cystectomy. The bulbourethral arteries will be encountered posterior to the bulbar urethra at the 4 and 8 o'clock position.

Partial Urethrectomy

For truly distal lesions, a partial urethrectomy could be performed to avoid a perineal urethrostomy and potentially allow a patient to stand to void. Adequate urethral length must be possible after resection or if a future reconstruction is planned; otherwise, it is better to proceed with a perineal urethrostomy. If considering a partial urethrectomy, it is important to ensure there are no more proximal tumors on cystourethroscopy.

With the patient in the supine position, a circumferential incision is made just beneath the corona and the penis is "degloved" along Buck fascia. Using a scalpel, the distal urethra with corpus spongiosum is excised along with a small cuff of glandular tissue. Frozen-section analysis must be performed to ensure the proximal urethra is disease-free. If negative margins are unable to be achieved, then an anterior urethrectomy, glansectomy, or partial penectomy should be performed to provide appropriate local control. In most cases in which negative margins are achievable, a penile urethrostomy is created. Depending on length of urethral defect, this can be left as a hypospadiac meatus or repaired at a later time using the same principles of a two stage urethroplasty for urethral stricture disease (14). It is prudent to wait at least 1 year prior to reconstructive surgery to confirm a recurrence-free state. Techniques of urethroplasty are described elsewhere in this book.

Surgical Treatment of Proximal Tumors of the Male Urethra

Most tumors of the proximal urethra are at a more advanced stage on initial presentation. Rarely there is a patient who is appropriate for endoscopic resection or segmental urethral excision with end-to-end anastomosis. For most cases of posterior urethral carcinoma, radical extirpative surgery is required to achieve disease control. Multidisciplinary care is highly encouraged to determine the role for chemotherapy and radiation therapy in individual patients.

Surgical treatment typically requires radical cystoprostatectomy with total urethrectomy or total penectomy, along with pelvic lymphadenectomy. If locally advanced, pubic rami resection and the adjacent urogenital diaphragm can be excised for wider margins to improve local control. This can be a morbid undertaking but provides the patient with the best opportunity for cure. The assistance of a plastic surgeon may be required for pelvic reconstruction usually with a myocutaneous flap, such as a gracilis muscle flap.

Bladder-sparing extirpative procedures have been described in carefully selected patients with tumors that do not involve the bladder neck. Bladder sparing requires closing the bladder neck with the creation of a catheterizable or noncontinent small bowel efferent limb (Monti procedure) to the abdominal wall or a permanent suprapubic tube. Any benefit of avoiding ureteroenteric anastomosis is, however, offset by the difficulties associated with bladder neck closure, particularly in irradiated patients or those who may require adjuvant or salvage pelvic radiation given the high risk of recurrence with surgery alone. The experience with radical urethrectomy and creation of continent catheterizable stoma is more robust and accepted in women with urethral carcinoma (15) and is further discussed in the following section.

Radical Cystoprostatectomy with En Bloc Urethrectomy

Our preoperative preparation is the same as we do for a radical cystectomy for bladder cancer. This consists of a clear liquid diet and oral magnesium citrate the day prior to surgery. Broad-spectrum antibiotics are given before incision to cover gram-positive, gram-negative, and anaerobic bacteria. Perioperative antibiotics are usually continued for 24 hours after surgery. Prophylactic subcutaneous heparin is given prior to induction of anesthesia and is continued throughout hospital stay along with early ambulation for thromboembolic prevention.

The patient is positioned in the low lithotomy position to allow simultaneous access to the abdomen and perineum. A two-team approach may be used to reduce operative time. The abdominal portion of the procedure is begun first via a vertical midline incision between the umbilicus and the pubis. The preperitoneal space is developed bluntly, and the bladder is mobilized in the usual fashion of a radical cystectomy, with the exception of the preservation of the puboprostatic ligaments. Fixed retraction with a Bookwalter device is used. Extended pelvic lymphadenectomy is performed from above the bifurcation of the iliac vessels to the node of Cloquet. Nodal packets are sent for permanent pathologic examination.

Next, the peritoneum is entered, the abdomen explored, and the bowel packed clear of the pelvis. Similar to a radical cystectomy for bladder cancer, the bladder is further mobilized and the ureters are divided as distal as possible while sparing as much periureteral tissue as possible. Frozen sections of the distal ureter should be sent to verify the absence of urothelial CIS. Dissection of the prostate is performed in an antegrade fashion without division of the puboprostatic ligaments, in the event en bloc resection of the pubis is required. Please see the chapter on cystoprostatectomy for a complete description of this surgical technique.

With the bladder and prostate widely mobilized, attention is directed to the perineal dissection (Fig. 41.3). An inverted U incision should be made with the apex of incision in the midperineum extending out to the ischial tuberosities to allow for the wide dissection often required to achieve negative margins. Deeper fixed retraction with an Omni-Tract or Thompson perineal retractor may be of benefit. Dissection is carried through the fascia and fatty tissue of the perineum. Blunt dissection is performed within the bilateral ischiorectal fossae, which are connected medially so that a tunnel anterior to rectum is developed beneath the central tendon in a similar fashion to a radical perineal prostatectomy. The central tendon is divided with electrocautery, followed by dissection of the rectourethralis muscle. With continued dissection, the rectum should be safely mobilized and the communication with the abdominal portion of the dissection should start to come into view. It is advisable to assess for unrecognized rectal injuries by inserting a finger into the rectum.

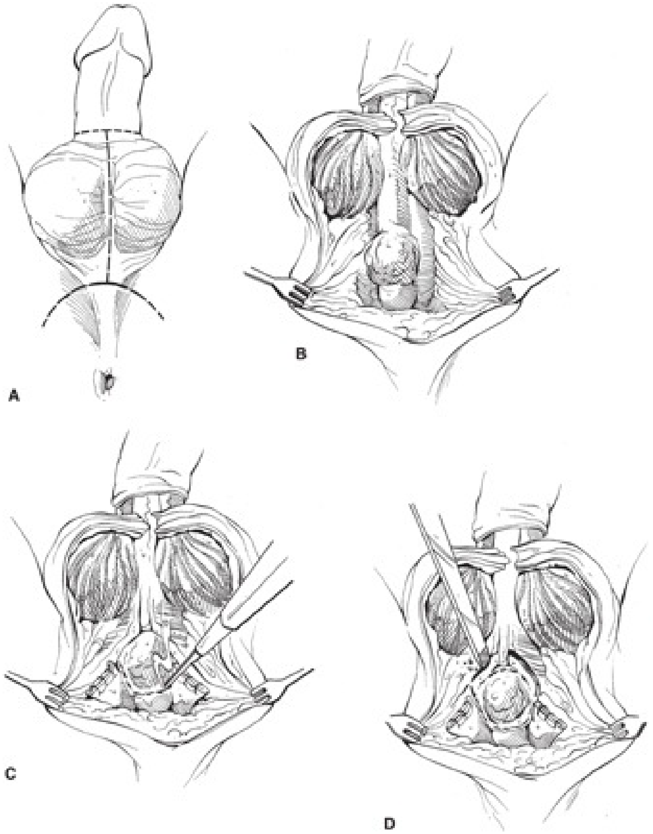

FIGURE 41.3 Perineal portion of radical cystoprostatectomy with en bloc penectomy and inferior pubectomy. **A and B:** Incision used to gain access to the perineum for total penectomy, total urethrectomy, radical cystoprostatectomy, and cutaneous urinary diversion. **C:** Electrocautery and suture ligatures are used to resect the urethral mass. **D:** If pubic bone invasion is present, the public arch is first scored with electrocautery; then, an orthopedic hammer and chisel are used to resect the inferior public arch to ensure a negative margin.

If total penectomy is required, the penile cura are dissected off their origin beneath the inferior pubic rami, and the division of the suspensory ligament further mobilizes the penis. The scrotum can be incised along the median raphe for increased exposure. If the tumor is invasive into the surrounding tissue, portions of the scrotum or perineal skin can be excised. Superficial thigh pouches can be created for the testicles if required.

It should also be determined if the inferior pubic rami needs to be resected en bloc to achieve negative margins. If so, orthopedic consultation is warranted. If only superficial involvement with tumor is present, only resection of the periosteum with electrocautery may be required. Deeper involvement of the pubic bone will require removal of the inferior portion of the pubic arch with orthopedic rongeurs, osteotome, reciprocating motor saw, or a Gigli saw. With the penis free, a negative surgical margin on the pubic arch and the cystoprostatectomy completed, the entire specimen is removed en bloc.

If pubectomy and penectomy are not required to achieve negative margins, then attention is given to mobilizing the membranous urethra from the urogenital diaphragm via the abdominal dissection using sharp and blunt technique. The puboprostatic ligaments are generally divided at this time, and control of the dorsal venous complex will need to be obtained. If penile preservation is attempted with the intention of nerve sparing, then electrocautery should be minimized at this point, as the neurovascular bundle runs posterolateral to the urethra. Once the entire cystoprostatectomy specimen with very proximal urethra is mobilized, anterior urethrectomy is completed via the perineal incision as described earlier. The specimen is removed en bloc (Fig. 41.4). Frozen sections should be sent to determine if addition resection is required.

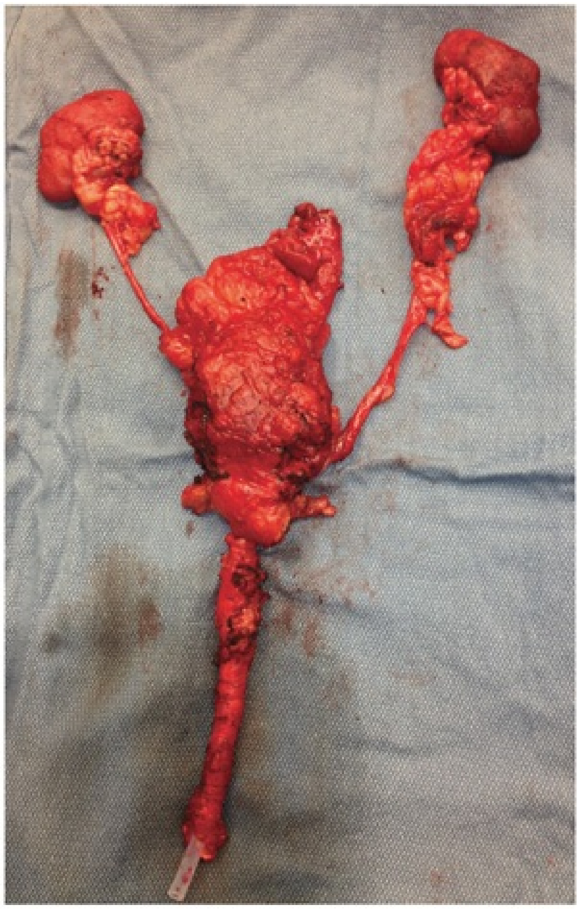

FIGURE 41.4 Radical Cystoprostatectomy with En Bloc Urethrectomy for proximal urethral adenocarcinoma. This patient was already on hemodialysis for end stage renal disease therefore bilateral nephroureterectomy was also performed

After the extirpative portion of the procedure is complete, a continent or noncontinent cutaneous urinary diversion is created depending on the individual patient. A complete discussion of the various types of urinary diversions is beyond the scope of this chapter but is covered in detail in other chapters within this book.

In the event of a large perineal defect after resection, consultation with a plastic surgeon is advisable because patients may benefit from a myocutaneous flap, such as a gracilis muscle flap. If only a small perineal defect is present and the perineal incision can be closed primarily, then thick skin flaps should be mobilized without undermining the cutaneous perforators to preserve a good vascular supply to the skin flap.

A least one perineal and one abdominal Jackson-Pratt drains should be used and brought out through a stab incision. The abdominal drain should be in close proximity to the ureteroenteric anastomoses. The superficial perineal fascia, deep dermis, and skin are closed with a running absorbable suture.

Complications

Major complications are uncommon after anterior urethrectomy, but perineal hematoma and superficial wound infections can occur. In addition, if pressure points are not properly padded in the lithotomy position, then peroneal nerve palsies or compartment syndrome can occur.

Complications from radical cystoprostatectomy with en bloc urethrectomy are common and are largely attributed to the morbidity associated with cystectomy and urinary diversion. Please refer to those chapters for a detailed discussion of those complications.

Resection of inferior pubis increases the risk of bleeding and stress urinary incontinence. Pelvic instability is typically minimal, as the superior pubic rami are usually enough to provide adequate support.

URETHRAL CARCINOMA IN WOMEN

Epidemiology, Etiology, and Risk Factors

Urethral carcinoma is an uncommon cancer in women. Like in men, the peak incidence of urethral carcinoma for women is in the eighth decade of life, and the tumor is also exceedingly rare before the age of 55 years. Also similar to men, the majority of women with urethral carcinoma are symptomatic at presentation (approximately 95% of patients). Symptoms of urethral carcinoma in women include irritative voiding, urinary obstruction, hematuria, a palpable urethral or anterior vaginal mass, and dyspareunia. Because the symptoms of urethral carcinoma overlap with many symptoms of benign diseases (urethral diverticula, caruncles, and urethral stenosis), there is often a delay in presentation of over 3 to 4 months (16). Symptoms, which do not respond to conservative measures, should be investigated to rule out a urethral cancer.

Few epidemiologic studies exist to completely understand the pathogenesis of the disease, but chronic inflammation, tobacco exposure, HPV infection, and recurrent UTIs have all been implicated. Unique to women is the development of carcinoma within a urethral diverticulum, although this is rare overall (1).

Diagnosis and Staging

A complete pelvic examination must be performed for a patient with suspected urethral cancer. Not only should the entire length of the urethra be inspected with palpation but a bimanual examination and rectal exam should also be performed. Other gynecologic and colorectal malignancies, which are often more common than urethral carcinoma, must be ruled out. If the tumor appears locally advanced and likely to require extensive resection, then preoperative plastic surgery consultation would be beneficial.

The drainage of the female urethra is similar to that in men; therefore, palpation of bilateral inguinal lymph nodes must also be done. The 15% to 30% of patients with urethral cancer will have nodal involvement at initial presentation (1).

Just as in men, cystourethroscopy should be performed to assess tumor extent and location with cold-cup biopsies or TUR to determine tumor histology. Biopsies distal and proximal to the tumor can provide useful information if organ-sparing surgery is considered. Complete cystoscopy examination to rule out concomitant bladder tumors is also mandatory. If bladder sparing is considered, it is important to also determine the distance of the tumor from the external sphincter and the bladder neck. The location of the ureteral orifices should also be noted along with a cystoscopic estimate of the bladder capacity.

Just as in men, MRI gives better information on soft tissue involvement and tissue planes over CT scan; therefore, MRI is beneficial to determine the depth of invasion of the tumor and to detect involvement of adjacent organs and structures in women. Some advocate for the usage of a transvaginal MRI coil. MRI or CT scan of the abdomen and pelvis should be performed to detect regional lymph node involvement. In the absence of lymph node involvement, a chest X-ray alone is adequate for staging. A bone scan is only required if signs or symptoms of bony metastasis are present.

Anatomy and Histopathology

The female urethra is 3 to 4 cm long from bladder neck to vaginal vestibule. It is arbitrarily divided into the proximal one-third (composed of urothelial cells and columnar squamous cells) and the distal two-thirds (composed of stratified squamous epithelium) (17). Similar in men, tumors in the distal female urethra have more favorable prognosis than proximal tumors (4). Tumor stage and nodal involvement are primary determinants of prognosis (4).

Although SCC was historically thought to be most common subtype of urethral carcinoma in females (18), it appears that UCC accounts for 30% to 45% of cases of urethral cancer, adenocarcinoma for 29%, and SCC for only 19% to 28% (1). The remaining 5% to 6% of urethral carcinoma are of various types including melanoma, sarcoma, etc. (1).

Patients with UCC of the urethra should be viewed as having a “field defect” within the lower urinary tract. We believe patients with invasive urethral UCC should not be candidates for urethral or bladder-sparing procedures and are best treated with radical cystourethrectomy. Cross-sectional upper tract imaging should also be obtained.

Alternative Treatments

As with men, the optimal management approach has yet to be established for women. Individual cases of urethral carcinoma should be discussed in multidisciplinary team meetings.

Distal urethral tumors have a more favorable prognosis and may be amenable to urethral sparing. Although the primary management of urethral carcinoma in men is usually surgery, radiotherapy is more often used in the treatment of female urethral carcinoma.

The most promising results for radiation therapy have been with a combination approach involving external beam radiotherapy and brachytherapy. A 5-year survival rate of 77% has been reported with combination radiotherapy, which is comparable to surgical series (16). Complications from radiation include urethral, vaginal, and rectal stenosis; fistula formation; cystitis; hemorrhage; and necrosis.

Urethra sparing with minimally invasive approaches, such as neodymium or holmium:YAG lasers, have also been reported but is discouraged in guideline discussion because of the high rate of local failure and the poor cancer-specific survival (1).

For more advanced urethral tumors, the failure of single-arm therapies to improve long-term outcomes has led to an interest in multimodal approaches. Although no optimal strategy yet exists, improved local control over surgery alone has been shown in most series looking at adjuvant radiation and neoadjuvant radiation (19). Neoadjuvant or adjuvant chemotherapy is used in patients with advanced disease, but this is guided by extrapolation from other cancers.

Surgical Treatment of Distal Tumors of the Female Urethra

Distal Urethrectomy

Tumors involving the distal third of the urethra, and especially those of the urethral meatus, are amenable to a distal urethrectomy. These patients and tumors must be carefully selected. Distal urethrectomy should be reserved for low stage ≤T2 tumors that are far enough distally from the external urinary sphincter that a safe margin of approximately 1 cm can be excised without jeopardizing urinary continence.

The patient is placed in high lithotomy position with the perineum at the end of the operating room table. After preparation and draping, visualization of the vaginal introitus is improved with the use of a weighted vaginal speculum, silk retraction suture for the labia, and a Lone Star retraction device. Trendelenburg position also improves visualization of the anterior vagina. A 16Fr Foley catheter is inserted to improve palpation and localization of the urethra and tumor during dissection.

The procedure is initiated with a circumcising incision around the urethral meatus (Fig. 41.5). The objective is to dissect out a full-thickness tissue plane of distal urethra from the surrounding tissue and achieve a negative margin. Grasping the urethral tissue with an Allis clamp allows for retraction and manipulation during dissection. The epithelium of the anterior vaginal wall can be incorporated en bloc in the posterior urethral dissection to ensure margins will be negative. With the use of the Foley catheter as a guide, both electrocautery and sharp dissection is used to free the urethra circumferentially. When adequate proximal dissection to allow at least a 1 cm surgical margin is completed, the Foley catheter is removed and the urethra is tied off to avoid any inadvertent tumor spillage. The distal urethra is then transected and the proximal urethral margin is sent for a frozen-section analysis. The placement of stay sutures into the proximal urethra can prevent migration out of the operative field.

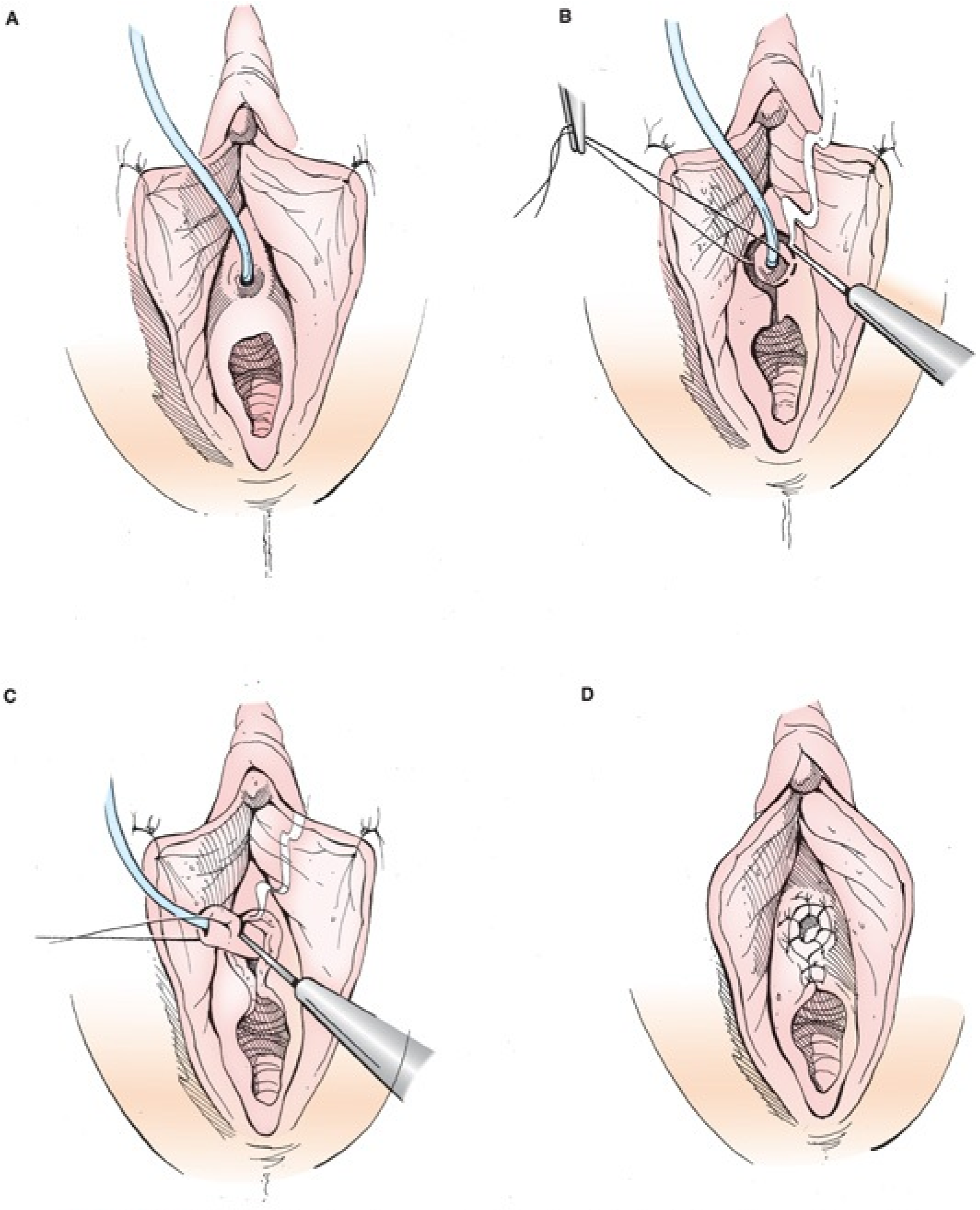

FIGURE 41.5 Technique of distal urethrectomy. **A and B:** A circumcising incision is made around the urethral meatus. **C:** The urethra is dissected free circumferentially to obtain at least a 1 cm surgical margin. **D:** The urethral stump is re-approximated to the edges of the vaginal incision with interrupted absorbable suture.

Next, the urethral stump is reapproximated to the edges of the vaginal incision with interrupted 3-0 Vicryl or other absorbable suture. The urethral stenosis can be prevented with the creation of wide neomeatus through spatulation of the ventral urethra. A new 16Fr Foley catheter should easily be inserted. The vaginal wall is then closed in two layers with 3-0 Vicryl sutures. Vaginal packing is placed and removed the following morning. The Foley catheter is removed in 7 days.

Distal urethrectomy does have a higher rate of recurrence (21%) but has an acceptable 5-year survival rate of 80% (15,16). The most common complications are urinary incontinence and meatal stenosis (15). Meatal stenosis should be minimized by adequate urethral spatulation. Urinary incontinence may be amenable to a urethral sling placed at a later time (16).

Radical Urethrectomy with Bladder Preservation

The high rate of local recurrence after distal urethrectomy can be reduced by radical urethrectomy with bladder sparing for distal urethral tumors not involving the bladder neck (15). Radical urethrectomy is certainly more appropriate than distal urethrectomy for larger tumors, but no comparisons against radical cystectomy exist.

With radical urethrectomy, all periurethral tissue up to pubic symphysis should be removed. Following resection of the diseased urethra, the bladder neck is closed and a urinary diversion is created (Fig 41.6). The diversion selected can be continent, such as a Monti procedure, or noncontinent, such as an ileovesicostomy. Because bowel is used for these diversions, the major gastrointestinal morbidity of a radical cystectomy is not avoided with this approach. Only the ureteroenteric anastomoses are avoided, but at a trade-off of bladder neck closure complications and unknown oncologic efficiency, because no comparisons between radical urethrectomy and radical cystectomy exist (20). A possible alternative is to use a permanent suprapubic tube as the urinary diversion, which avoids an intestinal resection and an abdominal incision if negative margins can safely be achieved through a vaginal approach only.

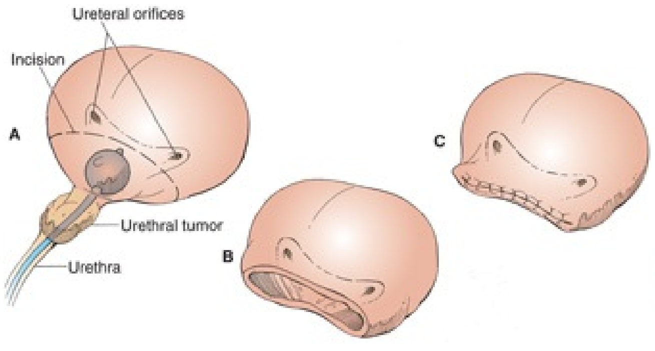

FIGURE 41.6 Technique of urethrectomy and bladder preservation by excision of the tumor at the level of the bladder neck, with subsequent bladder neck closure.

Radical urethrectomy with bladder preservation usually requires both an abdominal and vaginal approach. A simultaneous two-team approach may be used to reduce operative time. The patient is positioned in low lithotomy position. Prior to incision, cystoscopy is performed for additional confirmation that the bladder neck is uninvolved with tumor and for placement of bilateral ureteral catheters for later identification.

Abdominal exploration is begun through a lower midline incision. Pelvic lymphadenectomy can be performed at the start with lymph nodes sent for frozen-section analysis. Attention is then turned to mobilizing the bladder via dissection of the lateral pedicles and with incision of the endopelvic fascia, similar to a radical cystectomy. The urogenital diaphragm attachments to the urethra at the pelvic floor are excised with the use of electrocautery. The uterus and ovaries can be preserved if desired. Once sufficient mobilization of the bladder neck is achieved, attention is turned to the vaginal portion of the procedure.

The vaginal approach for a radical urethrectomy is the same as that described in the "Distal Urethrectomy" section except that dissection is continued proximally as high as possible. Because a radical urethrectomy is used for larger distal tumors, it is important to excise all periurethral tissues to ensure negative margins. As the abdominal and vaginal dissections meet, the pubourethral ligaments are divided to allow for en bloc removal of the entire urethra, anterior vaginal wall, and distal bladder neck.

Through the abdominal incision, the bladder neck is opened along its anterior surface. The ureteral orifices are identified with assistance of the ureteral catheters that were previously placed or placed at this point if cystoscopy was not done. At a safe distance distally from the ureteral orifices, the bladder neck is transected to allow for en bloc removal of the specimen. A frozen-section analysis should be taken from the bladder neck margin, and if positive, radical cystectomy should be done.

If the bladder neck margin is uninvolved with tumor, then the continent urinary division is created and the bladder neck is closed with running absorbable suture (see Fig. 41.5). A second additional layer of imbricating Lembert sutures for the bladder neck closure may be beneficial. An omental flap can be harvested to cover the suture line as an omental interposition to prevent fistula formation.

Several urinary divisions are possible for lower urinary tract reconstruction and a complete discussion of them is beyond the scope of this chapter, but readers are encouraged to review those chapters. After the abdominal stoma is matured, the vaginal defect is closed in two layers with absorbable suture. If a large vaginal wall defect is present, a regional flap may be necessary and consultation with a plastic surgeon is beneficial.

A 14Fr or 16Fr catheter should be traversing the stoma, a 20Fr or 22Fr suprapubic tube should be placed with at least one Jackson-Pratt drain near the bladder neck closure and omental interposition. Vaginal packing is placed and removed the following morning.

Surgical Treatment of Proximal Tumors of the Female Urethra

For patients with UCC, large tumors, or tumors involving the bladder base, anterior pelvic exenteration is indicated. Radical cystourethrectomy, pelvic lymph node dissection, and urinary diversion are performed in the standard fashion and are described in detail in other portions of this book. If the urethral tumor is large, then wide resection of anterior and lateral vaginal walls may be required. Similarly, en bloc resection of vulvar tissue may also be required to achieve negative margins (16). If inferior pubic rami resection is required, then the assistance of an orthopedic surgeon will be needed. Plastic surgeon consultation will also likely be needed for reconstruction of the pelvic floor for large resections.

Complications from radical cystourethrectomy are discussed in detail within the corresponding chapter, but common complications include wound infection and dehiscence, deep vein thrombosis/pulmonary embolism, and ileus/small bowel obstruction.

MANAGEMENT OF LYMPH NODES IN MEN AND WOMEN

In general, lymphatic drainage of proximal urethra is similar to bladder, which drains to obturator, iliacs, and presacral nodes for both males and females. The distal urethra drains to the superficial inguinal nodes followed by the deep inguinal and external iliac nodes. This is a similar pattern to penile SCC and vulvar cancer. Unlike penile cancer, enlarged inguinal lymph nodes are usually from metastatic spread and not from inflammation or infection (1). Between 15% and 30% of patients will present with nodal involvement, although palpable disease is not always present.

For both men and women, ilioinguinal lymphadectomy is indicated for clinically positive nodes without evidence of distant spread. The role for prophylactic inguinal lymphadectomy has yet to be established for urethral cancer (1).

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CHAPTER 42 INJECTABLE THERAPIES FOR INCONTINENCE IN WOMEN

STEPHEN MOCK, MELISSA R. KAUFMAN, W. STUART REYNOLDS, AND ROGER R.

Injecting material into the wall of the urethra to bulk the submucosal tissue layer, increase urethral resistance, and improve urethral coaptation is nothing new. Initially described in 1938, Murless et al. (1) reported on 22 women who had either morrhuate sodium or cod liver oil injected into the anterior vaginal wall to provoke an inflammatory response resulting in scar formation and contracture of tissue around the urethra. Seventeen patients reported being cured or improved, but pulmonary infarction and cardiopulmonary arrest were reported (1). In 1955, Quackels (2) reported on the first injections into the urethra using paraffin wax. Two patients were treated successfully without complications. In 1963, Sachse (3) used Dondren, a sclerosing agent, to treat 7 women and 24 men. Four women and 12 men were reported as cured, but several patients experienced pulmonary embolism (3). In the 1970s and 1980s, polytetrafluoroethylene (PTFE; Teflon) was used extensively (4) but was never approved for use in the United States, owing to safety concerns including distant particulate migration and foreign body reaction (5). Autologous fat was studied and in a randomized double-blind controlled trial of women with urethral hypermobility was found to be as effective as the saline control group at 6 months (6). Additionally, serious adverse events including systemic embolization and death have been reported (7,8). Ethylene vinyl alcohol copolymer (Tegress), a permanent, hypoallergenic, nonimmunogenic implant, demonstrated equivalence in outcomes with collagen (9,10) and was approved by the U.S. Food and Drug Administration (FDA) in 2004. However, the high rate of urethral erosion, although generally self-limited with spontaneous resolution, contributed to bothersome dysuria and necessitated multiple office visits (11), and as a result, the manufacturer voluntarily withdrew Tegress from the market in 2007. As illustrated, these bulking agents were far from ideal. Such an ideal agent would be nonimmunogenic; hypoallergenic; biocompatible; permanent; nonerosive; heal with minimal fibrosis; be nonmigratory; easily stored, handled, and injected; painless; and retain its bulking effect over a long period of time (be durable) (12,13). The components of the agent should not separate or dissociate on injection, and if the agent contains microcrystalline or micropolyermic components, they should be reasonably uniform spheres of particle sizes above 110 μm so as to minimize the risk of migration. If the substance used is not successful, it should not interfere with subsequent surgical intervention (12). To date, no agent has satisfied all these requirements, and the search continues for improved materials and modes of delivery.

MECHANISM OF ACTION

Injectable agents work by forming a “hermetic seal” through restoration of mucosal coaptation during the storage phase and maintain this coaptation during periods of increased abdominal pressure. It is generally thought that these agents improve intrinsic sphincter function, as evidenced by an increase in postinjection abdominal leak point pressure (ALPP), which is the amount of abdominal pressure necessary to overcome the bladder’s continence mechanism (14). They have several advantages over surgical procedures in treating stress urinary incontinence (SUI). Compared to surgical procedures that create a functional obstruction, injectable agents restore continence by increasing urethral resistance at rest. With bulking agents, the urethra maintains its ability to funnel and open, keeping urethral resistance low during micturition. This spares a resultant increase in detrusor pressure, which could lead to overactive bladder symptoms and/or upper tract damage. In comparison, surgical procedures may result in increased resistance at rest and during micturition by not allowing the urethra the same physiologic movement. Most bulking agents are placed at the level of the bladder neck within the smooth muscle in the area of the continence mechanism. Since the placement is within the urethra, *intraurethral* is a more accurate term than the commonly used terms *periurethral* or *submucosal*.

CRITERIA FOR SELECTION

Traditionally, intraurethral bulking agents were reserved for women who have SUI due to intrinsic sphincter deficiency (ISD), a normal contractile bladder, and limited urethral mobility (<30 degree change in axis on cotton swab test from rest to strain). However, multiple reports have demonstrated clinical efficacy in patients with urethral hypermobility. In one study, both those with and without hypermobility had equal success, although more injections and a greater amount of material were injected in the group with urethral hypermobility (15). In a later study by Herschorn and Radomski (16), no statistically significant difference was found between those with and without urethral hypermobility. Over time, 72% remained dry at 1 year, 57% at 2 years, and 45% at 3 years, with no significant difference between the type of incontinence and time to failure. Others have documented similar findings (17–20).

Currently, good candidates for bulking agents include those who are poor surgical candidates and are at high anesthetic risk, are elderly and at greater risk of retention after a sling procedure, must continue anticoagulation at all times, are unable to follow postoperative activity limitations required after anti-incontinence procedures, are young and desire more children in the future, have mild persistent SUI after an anti-incontinence procedure, have SUI and poor bladder emptying, have mild SUI associated with exercise, do not wish to undergo more invasive procedures, and are willing to accept an improvement rather than a cure of their SUI symptoms (13). Patients must understand that efficacy and duration of these agents are inferior to surgery and follow-up injections may be required.

Urodynamics should be performed to rule out other causes of urinary incontinence, such as detrusor overactivity. Urethral function can be assessed by measuring the ALPP, and the definition of ISD by ALPP has varied from a low ALPP (60 cm H_2O) to an ALPP <100 cm H_2O. An absolute value for ALPP suggesting ISD has become unimportant due to limitations in urodynamic testing as well as different values used by different clinicians. With videourodynamics, radiographic evidence of an open bladder neck and proximal urethra without detrusor contraction during the storage phase of the bladder is felt to imply ISD.

As more is understood about the continence mechanism, it appears that most women with SUI have some component of ISD, since there are numerous women with urethral hypermobility who do not leak with significant intra-abdominal pressures. Women who do have a fixed, nonmobile urethra are, however, more likely to have a greater degree of ISD (21). Exclusion criteria for intraurethral bulking would include urinary incontinence due to abnormal detrusor contractions, active urinary tract infection (UTI), or allergy to the material used as a bulking agent.

Key Concepts

- *Ideal patients for intraurethral bulking have SUI due to ISD, a normally contractile bladder, and urethral mobility less than 30 degrees.*
- *The efficacy and duration of bulking agents are inferior to surgery and follow-up injections*

may be required.

- *Most women with SUI have depressed ALPP and some components of ISD.*

INJECTION TECHNIQUES

Bulking agents are generally administered with cystoscopic assistance under local anesthesia. The two most accepted techniques are periurethral and transurethral and both are retrograde suburothelial approaches. The transurethral approach is more commonly performed today. Antegrade placement has also been described but is rarely used today because it necessitates suprapubic access. Precise placement of the bulking material into the wall of the proximal urethra near the bladder neck in the area of the continence mechanism is of the utmost importance. The plane of delivery, the tissue quality at the injection site, and the cause of incontinence are all important factors in successful therapy. If material is delivered too distally, the treatment is likely to fail and may cause irritative voiding symptoms. Prior to injection, patients are placed in lithotomy position and prepared in standard sterile fashion. Preoperative and postoperative antibiotics are frequently administered. A local anesthetic in the form of 20% benzocaine ointment or cream may be applied to the vestibule covering the urethra, and a topical 2% lidocaine jelly may be applied to the urethra. Perimeatal blebs are raised with 1% or 2% lidocaine at the 3 and 9 o'clock or 4 and 8 o'clock positions 3 to 4 mm lateral to the urethral meatus using a 25-gauge needle and then, approximately 4 mL of 1% or 2% lidocaine is injected periurethrally.

Key Concepts

- *Precise placement of the bulking material into the wall of the proximal urethra near the bladder neck in the area of the continence mechanism is of the utmost importance.*

TRANSURETHRAL INJECTION

The transurethral technique consists of the bulking agent injected submucosally via a needle inserted through a conventional cystourethroscope under direct vision (22). Endoscopic instrument companies have an array of equipment designed for transurethral injections. The needle size depends on the viscosity of the agent, and some require special ratcheted injection guns to generate enough pressure to overcome this viscosity. A 0-, 12-, or 30-degree lens is best for providing a good view of the urethra as well as the injection needle. Once the cystourethroscope is placed into the urethra and passed into the bladder, the bladder is usually drained because the patient's bladder may become distended toward the end of the procedure. The endoscope is then backed to the midurethra, at which time the needle can be deployed. Injections have been described at different locations (e.g., 3 and 9 o'clock; 4 and 8 o'clock) such that coaptation, either horizontal or concentric, is achieved. For the initial injection, the 6 o'clock position is often an ideal starting point. The distance from the point of penetration of the urethra to the bladder neck has to be greater than the length of the needle to prevent extravasation of the agent into the bladder. The needle is then inserted submucosally into the urethral muscle beyond the midurethra and advanced to the proximal urethra near the bladder neck. Once the desired positioning is achieved, the bulking agent is slowly delivered to allow it to spread underneath the urethral mucosa. Once the mucosa on that side has expanded to the midline, the needle is slowly withdrawn while injecting. In general, the amount of material needed is the amount that achieves complete coaptation. Of note, once this point is reached, the cystoscope should not be advance past the bulked-up urethra and bladder neck so as to avoid possibly compressing or causing extravasation of the injected agent.

Key Concepts

- *Injections have been described at different locations (e.g., 3 and 9 o’clock; 4 and 8 o’clock) such that coaptation, either horizontal or concentric, is achieved.*
- *In general, the amount of material needed is the amount that achieves complete coaptation.*

PERIURETHRAL INJECTION

Injections may also be performed periurethrally via a needle placed percutaneously lateral to the urethral meatus and parallel to the urethra. While the needle is placed, the urethra is visualized through a cystourethroscope (23). Localization of the needle tip may be facilitated by preinjecting the urethra with methylene blue during the periurethral approach (24). With the periurethral approach, there is often less bleeding, which can improve visualization. There is also less extrusion of the material injected, although this also depends on the type of material injected. The desired amount of coaptation is the same as when performed via a transurethral technique. After the periurethral block, a 20-gauge spinal needle is placed at the 3 or 4 o’clock position into the periurethral tissue within the lamina propria. Urethroscopy is then performed as the needle is further inserted with minimal resistance up to the level of the bladder neck. The surgeon can hold the cystoscope in one hand and advance the needle with the other, but in our experience, an assistant is beneficial. The needle is then rocked in a horizontal plane to assess the location of the needle tip and ensure placement at the proper depth. The material is then injected slowly while observing for coaptation, similarly to the transurethral technique, and the process is repeated at the 8 or 9 o’clock position. If material is noted in the lumen of the urethra, the needle is removed and relocated to a more anterior position, where the injection is repeated again. Once sufficient coaptation is noted, the procedure is ended. A needle with a “bent tip” has been manufactured (Boston Scientific Inc, Natick, Massachusetts) to facilitate placement into the proper plane. With advancement of the needle, the tip is brought more medially. These needles are of a larger bore size (18 or 20 gauge) and were originally designed to ease the injection of the larger caliber particles of Durasphere, but they certainly can be used for the periurethral injection of other bulking agents.

The differences between the transurethral and periurethral techniques were reviewed by Faerber et al. (25), and they found similar outcomes with no significant differences in adverse events using collagen as the test bulking agent. Of significance, the amount of material injected was less using a transurethral approach. A prospective, randomized comparison was later performed in women with no noted differences in efficacy, but a higher rate of urinary retention and an increased volume of injected material were seen in the periurethral group (26). It appears that a periurethral approach tends to use larger volumes of material and has been noted to have a longer learning curve than the transurethral approach. This is important as greater volumes are associated with higher cost and may increase the potential for postoperative complications.

Key Concepts

- *The desired amount of coaptation is the same as when performed via a transurethral technique.*
- *Efficacy is similar between periurethral and transurethral techniques, but the periurethral approach tends to use larger volumes of material and has been noted to have a longer learning curve than the transurethral approach.*

POSTOPERATIVE CARE

Immediate postoperative complications are rare. After completion of the procedure, the patient should demonstrate the ability to void. If the patient is in acute urinary retention, most often the patient will be able to urinate shortly after the periurethral block loses effect. In the meantime, the patient is usually catheterized with a small 10Fr to 14Fr catheter to relieve the patient's full bladder after cystourethroscopy. An indwelling Foley catheter should be avoided since there is a theoretical risk of the bulking agent molding around the catheter and losing its effect, although there is no evidence to support that short-term catheterization decreases the efficacy of intraurethral bulking. If long-term catheterization is necessary, a suprapubic catheter until return of voiding would be best to avoid disrupting the placement of the bulking agent. Although there are no randomized trials on the use of prophylactic treatment with antibiotics, a fluoroquinolone or trimethoprim-sulfamethoxazole for 24 hours or less can be recommended (27). An additional 2 to 3 days has also been suggested (28).

Many patients will require more than one treatment session to achieve maximal continence. Different waiting periods are required for each individual bulking agent. Bulking agents such as glutaraldehyde cross-linked bovine collagen (GAX-collagen) can be repeated after 7 days (in the original multicenter study, a 4-week waiting period was used), but most clinicians wait 4 weeks or longer to assess response and the need for reinjections (28). With Teflon, a 4-month wait is required because improved coaptation occurs with time. Macroplastique injections can be repeated after 12 weeks. Durasphere can be reinjected after a minimum of 7 days and Coaptite can be reinjected after 1 month or less. On repeat injection, if erosion is noted, injection into that side should be avoided until re-epithelialization occurs.

Irritative voiding symptoms may also develop after placement of bulking agents. Surprisingly, in a study by Steele et al. (19), 50% of patients were reported to have developed de novo detrusor overactivity. In a study by Cross et al. (29), 28% of patients were found to have de novo urge incontinence without ISD when undergoing urodynamics for posttreatment incontinence. Stothers et al. (30) reported a 12.6% rate of de novo urgency with urge incontinence in 337 women enrolled in a prospective trial of which 21% failed anticholinergic treatment.

Reports have been published on rare complications including urethral mucosal prolapse, abscesses, periurethral pseudocyst formation, and urethral diverticuli (13). Additionally, the periurethral approach is associated with higher injection volumes, which may contribute to higher urinary retention rates (26).

Key Concepts

- *Although uncommon, if a patient is in acute urinary retention, catheterization with a small 10Fr to 14Fr catheter to relieve the patient's full bladder is indicated.*

INJECTABLE AGENTS

Many different agents have been studied for use as bulking material with varying success and adverse events (Table 42.1). A Cochrane review from 2012 that identified 14 clinical trials and over 2,000 women found trials to be small and of moderate quality. They concluded that due to the “lack of long term follow up and health economic data . . . injection therapy cannot be recommended as an alternative for women fit for other surgical procedures,” but for “women with extensive co-morbidity precluding anesthesia, injection therapy may represent a useful option for relief of symptoms, at least for a 12 month period” (31). Patients should be counseled that greater symptomatic improvement is observed after surgery but at the expense of higher risks. Women should be made aware that repeat injections are likely to be required, efficacy diminishes over time, and that this therapy is inferior to more invasive techniques.

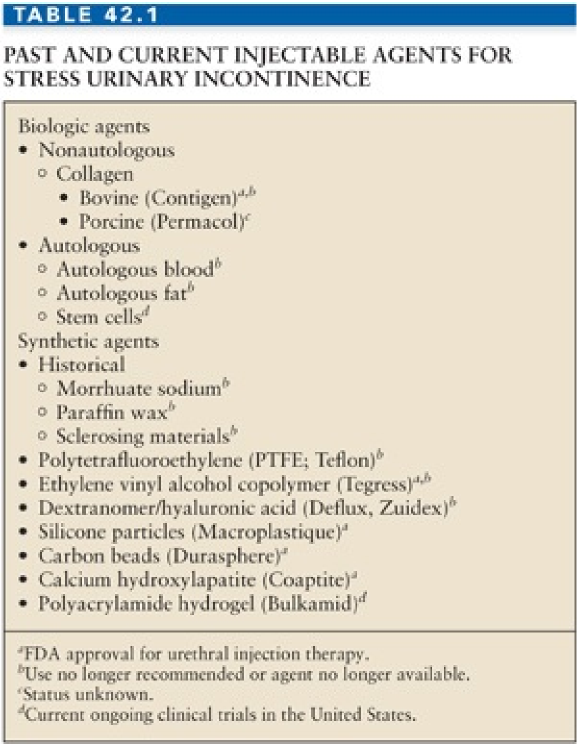

TABLE 42.1

PAST AND CURRENT INJECTABLE AGENTS FOR STRESS URINARY INCONTINENCE

Biologic agents
- Nonautologous
  - Collagen
    - Bovine (Contigen)[a,b]
    - Porcine (Permacol)[c]
- Autologous
  - Autologous blood[b]
  - Autologous fat[b]
  - Stem cells[d]

Synthetic agents
- Historical
  - Morrhuate sodium[b]
  - Paraffin wax[b]
  - Sclerosing materials[b]
- Polytetrafluoroethylene (PTFE; Teflon)[b]
- Ethylene vinyl alcohol copolymer (Tegress)[a,b]
- Dextranomer/hyaluronic acid (Deflux, Zuidex)[b]
- Silicone particles (Macroplastique)[a]
- Carbon beads (Durasphere)[a]
- Calcium hydroxylapatite (Coaptite)[a]
- Polyacrylamide hydrogel (Bulkamid)[d]

[a] FDA approval for urethral injection therapy.
[b] Use no longer recommended or agent no longer available.
[c] Status unknown.
[d] Current ongoing clinical trials in the United States.

Comparing the different injectable agents is a difficult task. There are few controlled, long-term studies involving commonly used bulking agents. Even within those rare studies, there are many variables that make it difficult to compare them. Not all studies differentiate the results in patients with and without urethral hypermobility and/or ISD. The procedures themselves are also varied due to different technical factors such as injection technique and instrumentation. Additionally, reported results have been largely subjective rather than objective, creating a difficult situation to compare data. Variability also exists within the reported outcomes, as different criteria have been used to define cured or improved. Also, because agents can be repeated if not successful, the time frame in the determination of a successful outcome can impact overall rates. For example, if the duration of results is reported from initial treatment or is not specified, success rates may be overestimated because failures can be retreated and can be considered a success within the follow-up period.

BIOMATERIALS

Glutaraldehyde Cross-Linked Bovine Collagen (Contigen)

Of all the injectable agents, GAX-collagen is probably the most commonly used, with numerous publications describing its safety and efficacy. It has been considered the gold standard of urethral bulking material such that the FDA required direct comparison to collagen for any new bulking agents in clinical trials (32). GAX-collagen is derived from bovine collagen that is cross-linked with glutaraldehyde to create a stabilized, fibrillar collagen that confers resistance to denaturation by collagenases, thus increasing the durability of the implant (33). It consists of 35% purified bovine collagen in a phosphate buffer. The collagen itself is composed of 95% type I collagen, which is the type found predominately in ligaments and confers structural strength; however, between 1% and 5% is composed of type III collagen, which is the type abundant in vaginal tissue, giving added flexibility (34).

When injecting this material, the surgeon inserts the exact amount needed to achieve the desired effect, since there is no expansion or shrinking after injection. Acting as a matrix, the material promotes ingrowth of new collagen within the implant (35). Since GAX-collagen is both biocompatible and biodegradable, only minimal inflammatory changes occur (36). It is not known to migrate. After 12 weeks, the collagen starts to degrade, but it persists until 19 months (37). Despite the fact that GAX-collagen is degraded, it maintains effectiveness in 80% of those who become continent, a result that is thought to be secondary to the ingrowth of new collagen (38).

In a multicenter clinical study involving 127 women with ISD who had GAX-collagen injection, at 2 years, 46% of patients were dry and 34% were significantly improved, requiring only a single pad or tissues. Urodynamic studies also revealed a rise of 40 cm H_2O in ALPP. A mean volume of 18.4 mL of GAX-collagen with a mean of 2.1 (+/− 1.5) treatment sessions was given to those who achieved continence (39). Other independent studies have supported these results (40,41). As time progresses, a noted decline in efficacy has been witnessed. Forty-five percent of elderly women were improved at 24.4 months in a report by Winters et al. (18), but of note in this group, 40% required more injections after an average of 7.9 months. At 50 months, Corcos and Fournier (42) reported a cured rate of 30% and an improved rate of 40% in 40 women, although 4 women in the cured group and 5 women in the improved group required “maintenance” injections (42). In a study up to 5 years, Gorton et al. (43) reported that only 26% of 53 women reported continued improvement. Herschorn et al. demonstrated the probability of remaining dry after the last collagen injection was 72% at 1 year, 57% at 2 years, and 45% at 3 years (44).

Few complications have been found with the use of GAX-collagen. In the U.S. clinical trials (45), 15% developed transient urinary retention, 5% had a UTI, and 1% experienced irritative voiding symptoms. Rates of de novo urgency and frequency have been reported to be as high as 10% (42). There has been no evidence of foreign-body response or migration (36), partly because of the small amount of glutaraldehyde in GAX-collagen, which creates minimal immunoreactivity and cytotoxicity (46). GAX-collagen is biocompatible and allows fibroblasts to deposit native collagen as well as allow neovascularization to occur as the implant is degraded over 12 weeks (47). After 10 to 19 months, all of the implant has completely degraded (37). There have been several case reports of sterile abscesses at the injection sites, some of which required drainage (48).

One potential hazard of GAX-collagen involves an allergic reaction to the bovine protein, although this is reduced by cross-linking and skin testing, which all patients must undergo 30 days before treatment. Approximately 4% of female patients will have a positive skin test, with 70% showing the reaction within 3 days, which indicates a preexisting sensitivity to bovine dermal collagen through dietary exposure. The remaining 30% do not respond until later so a 4-week period is required. A positive test precludes them from treatment (39), but a negative test does not preclude the development of a hypersensitivity reaction to subsequent treatment.

Overall, due to its complete degradation with minimal inflammatory response and lack of migration, GAX-collagen has been the most popular intraurethral bulking agent used to treat incontinence. However, despite its long track record, although with modest results, the manufacturer ceased production in 2011, and the implant is no longer available.

Key Concepts

- *As time progresses, a noted decline in efficacy has been witnessed.*
- *Approximately 4% of female patients will have a positive skin test, which precludes them from treatment.*
- *The manufacturer has ceased production, and GAX-collagen is currently no longer available.*

SYNTHETIC MATERIALS

Silicone Polymers (Macroplastique)

Macroplastique (Uroplasty Inc, Minneapolis, Minnesota) is made of vulcanized polydimethylsiloxane macroparticles suspended in a carrier hydrogel consisting of polyvinylpyrrolidone (povidone) that also serves as a lubricant for the injection system. It is absorbed by the reticuloendothelial system and is excreted unchanged in the urine. Macroplastique consists of particulates of various shapes and sizes with marked variability: The particles can range from less than 50 μm to 400 μm in largest dimension, but 99% of the particles are greater than 100 μm. Still, the concern for potential particulate migration is present, especially for small particles less than 70 μm. In a study to determine the migratory properties of this material performed on dogs, small particles were found in the lungs, kidney, brain, and lymph nodes within 4 months of injection. In comparison, only one large particle was found in the lung without any associated reaction (49).

Macroplastique requires no pre-administration hypersensitivity testing, and the material does not require refrigeration or special handling. It is supplied in preloaded 2.5 mL syringes, and because the substance is fairly viscous, it requires high-pressure injection accomplished via an 18-gauge Uroplasty rigid endoscopic needle gun along with standard cystoscopic equipment. Alternatively, a proprietary, nonendoscopic transurethral injection device, the Macroplastique implantation system (MIS) can be used. The MIS consists of a multichanneled needle positioning device with three angled needle entry ports orientated at 2, 6, and 10 o’clock positions for injections of 1.5 mL, 2.5 mL, and 1.5 mL of material, respectively. This is also the recommended endoscopic injection technique for Macroplastique. The MIS is currently not available in the United States.

Silicone polymer was first used for the treatment of SUI in 1992 with encouraging short-term follow-up. Like other agents as time progressed, the cure rate fell from an initial 82% to 70% at 14 months (50). A recent North American multicenter randomized trial randomized, 247 patients with ISD to transurethral injection of either Macroplastique or Contigen. After 12 months, there were significant clinical improvement and dry/cure rates in 61.5% and 36.9% of patients treated with Macroplastique, respectively, versus 48% and 24.8% of patients treated with Contigen, respectively. This indicated that Macroplastique was noninferior to Contigen ($P < .001$). There were no differences in pad weight testing, quality of life scale, or adverse events between the two groups (51). Two-year follow-up reporting of the Macroplastique group demonstrated, of those who had a benefit at 12 months, 84% maintained that level of cure or improvement to 24 months. Based on this, of the original 122 patients at the beginning of the study, 51.7% had a good outcome at 2 years (52).

Complications with the use of this material included urinary retention at a rate of 5.9% to 17.5%, urinary frequency at a rate of 0% to 72.4%, dysuria from 0% to 100%, and UTI from 0% to 6.25% (53).

Key Concepts

- 🟩 *Due to its viscous nature, Macroplastique requires a special ratchet needle gun for administration.*
- 🟩 *Particle migration is rare but is a theoretical risk given the small percentage of particles less than 70 μm.*
- 🟩 *Macroplastique is noninferior in efficacy to Contigen.*

Durasphere

Durasphere is composed of nonabsorbable pyrolytic carbon-coated zirconium oxide beads suspended in a 2.8% beta-glucan water-based gel. The bulking effect lasts for at least 2 years as the beads are encapsulated into the periurethral tissue. Compared to collagen, it is an inert and nonimmunogenic material and eliminates the need for skin testing. It gained FDA approval for use in patients with ISD in 1999. Standard cystoscopic equipment and proprietary 18-gauge injection needle device can be used. A bent needle (18 or 20 gauge) is available for periurethral injection. It comes in 1 mL or 3 mL filled syringes. Because of the safety concerns of particle migration, Durasphere was designed with larger caliber particles (>80 *μ*m) to prevent migration. The bead size ranges from 212 to 500 *μ*m, but as a consequence, Durasphere can be more technically difficult to inject given its higher viscosity, with the beads clogging the needle, leading to increased resistance with resulting higher pressures required to inject the material. A modified injection technique was introduced to overcome this difficulty by injecting a local anesthetic into the mucosa to raise a circumferential bleb into which Durasphere is injected (54). Additionally, as a way to remedy this, the manufacturer introduced Durasphere EXP in 2006, whose smaller bead size (range 90 to 212 *μ*m), facilitates injection but still larger than the threshold for migration. As of late 2013, no clinical results have been published with this new formulation nor does there appear to be any open clinical trials ongoing.

Durasphere was compared to GAX-collagen in a multicenter, randomized, controlled, double-blind study. At the 1 year follow-up, the Durasphere group achieved improvement in one Stamey grade or more in 80% of patients compared to 69% of patients in the GAX-collagen group, although the difference did not reach statistical significance. Pad weights at 12 months were equivalent between the two groups. The Durasphere group had significantly less volume of material injected and was more successfully treated with a single injection, but 45% of the study patients who had 1 year follow-up after the last injection were not accounted for (55). Long-term data have been reported, and as in the case of many injectable agents, there is a decrease in clinical success. Durasphere was effective in 33% of patients at 24 months and in 21% at 36 months. Those who received GAX-collagen reported effectiveness in 19% of patients at 24 months and in 9% at 36 months. However, when controlled for differences in follow-up time, the time to failure between the two groups did not reach statistical significance. Interestingly, one-third of each group felt that treatment was successful (56).

In the trials for FDA approval, the most common adverse events were acute retention ≤7 days at 13%, dysuria at 12%, UTI at 9%, hematuria at 6%, and retention >7 days at 6%. Other adverse events occurred at ≤4% (57). From the multicenter randomized trial of Durasphere versus GAX-collagen, adverse events were similar between the two groups, except for a higher incidence of urgency and acute retention in the Durasphere group (24.7% and 16.9%, respectively) than in the collagen group

(11.9% and 3.4%, respectively), but regarding the urgency symptom, a higher percentage (90%) resolved by study end in the Durasphere group than in the collagen group (65%), (*P* = .021) (55). There have also been case reports of sterile abscess formation and urethral prolapse (58,59).

Key Concepts

- *Durasphere EXP, a modification of the original Durasphere that allows lower pressure injection due to its smaller bead size (range 90 to 212 μm) was introduced to facilitate injection but is still larger than the threshold size for migration.*
- *Durasphere achieved improvement in one Stamey grade or more in 80% of patients compared to 69% of patients in the GAX-collagen group, although the difference did not reach statistical significance.*

Calcium Hydroxyapatite (Coaptite)

Approved in December 2005, calcium hydroxyapatite is a synthetic agent that consists of carboxymethylcellulose and glycerin in the form of an aqueous gel. Calcium hydroxyapatite is manufactured into particles of spherical mean diameter of 100 μm (75 to 125 μm), which is above the threshold for migration. The gel facilitates injection and provides the initial bulking effect but is designed to degrade over time and allowing for ingrowth of tissue around the particles. It is a normal constituent of bone and teeth and has been used in orthopedic and dental applications as well as soft tissue augmentation of vocal cord, face, and the ureteral orifice for vesicoureteral reflux with excellent biocompatibility (60,61). As a result, a pre-procedure skin test for hypersensitivity is not required. It does not require refrigeration or special handling.

The implant is currently dispensed in 1 mL prefilled syringes and can be performed via standard endoscopic instruments with a supplied 21-gauge rigid injection needle with either an end-firing or side-firing capability. Ease of injection is a noted advantage. Approximately 2 to 4 mL of material is required for coaptation. Calcium hydroxyapatite is radiopaque and can be seen on radiographic images, which may aid in accurate localization and placement (12).

In a study with 1-year follow-up, 7 of 10 women reported substantial improvement in continence, a 90% decrease in mean pad weight, and an increase in mean Valsalva leak point pressure from 39 to 46 cm H_2O (62). In the data for FDA approval, 158 patients received Coaptite with a mean follow-up of 11.2 months, and no statistical difference was found in change in Stamey grade, pad weight, or quality of life when compared to GAX-collagen as the control (63). A large multicenter randomized clinical trial randomizing 296 women with ISD to either Coaptite or collagen has been reported. At 12 months, 63.4% of the Coaptite group showed improvement of one Stamey grade or more versus 57% in the collagen group (*P* = .34). There was no difference in cure rates (39% Coaptite versus 37% collagen). Up to five injections were performed in the first 6 months of the trial. More patients in the Coaptite group required only one injection (38%) compared with the collagen group (26.1%) (*P* = .03), and the total average injected volume was lower (4.0 mL versus 6.6 mL, $P < .0001$) (64).

Common adverse events included urinary retention (41%), hematuria (19.6%), dysuria (15.2%), and UTI (8.3%). Changes in voiding occurred with urinary urgency at 7.6%, frequency at 7.0%, and urge incontinence at 5.7%. Two serious adverse events occurred: erosion through the vaginal wall requiring surgery and dissection into the bladder causing tissue bridging, for which no surgical correction was needed. It was posited that these were unlikely the result of direct tissue toxicity of

Coaptite but rather due to increased prolonged tissue pressure effects from its greater particle density than collagen. No long-term sequelae of these two events were noted. The overall erosion rate was 1.3% (63).

Key Concepts

- *No statistical difference was found in change in Stamey grade, cure rates, pad weight, or quality of life when compared to GAX-collagen as the control; however, significantly more patients in the Coaptite group required only one injection and the total average injected volume of material was lower.*

Polyacrylamide Hydrogel (Aquamid, Bulkamid)

Aquamid and Bulkamid are polyacrylamide hydrogels that are nontoxic and nonresorbable sterile aqueous gels consisting of 2.5% cross-linked polyacrylamide and 97.5% nonpyrogenic water. It is homogenous and has a tissue-like viscosity and elasticity. It contains no solid particles thereby eliminating any risk of particle migration. Aquamid is used clinically as soft tissue filler in plastic surgery and reconstructive procedures in Europe. Bulkamid is the corresponding product for the SUI indication. It does not need refrigeration or any special handling and is supplied in preloaded 1 mL sterile syringes. It can be injected transurethrally using a 23-gauge needle and standard cystoscopic equipment or via a proprietary endoscopic system, the Bulkamid urethral bulking system. This system is specially designed to facilitate injections and consists of an 11-cm female urethra urethroscope and a disposable rotatable sheath with a working channel for the needle that allows for 360-degree rotation. Approximately 0.5 mL of material is injected each at the 3, 6, and 9 o’clock position to achieve full coaptation (13).

Bulkamid is used clinically for endoscopic treatment of SUI in Europe. An open, noncomparative, multicenter case series of 135 women was reported in 2010. Half the patients had mixed urinary incontinence. At 12 months, two-thirds of the women reported being cured or improved, and there were significant reductions in incontinence episodes per 24 hours and pad weight testing. Efficacy was similar between patients with pure SUI and those with mixed incontinence. There was a 35% reinjection rate. Minor adverse events noted included UTI (5%), transient urinary retention (3%), hematuria (1%), and transient de novo urgency and urge incontinence (1%) (65). In the 2-year follow-up analysis of this cohort, there was durability of success with 64% of women cure/improved, which was not significantly different compared with the 12 month data (66).

Bulkamid and Aquamid are currently not approved for use in the United States, but multicenter randomized clinical trials are ongoing in North America and Europe.

Key Concepts

- *Bulkamid is used in Europe for the treatment of SUI, but no randomized controlled data have been published. It is currently not approved in the United States, but trials are ongoing.*

Permacol

Permacol is a dermal implant made from nonreconstituted porcine dermal collagen and has been used in hernia repairs and pelvic reconstruction. Noncollagenous material, except elastin, is removed and a cross-linking process is performed. It maintains its original three-dimensional form, and when implanted, it allows for ingrowth of new tissue, which can potentially be permanent (67). Permacol is nonallergenic, obviating the need for skin hypersensitivity testing.

One study compared Permacol and Macroplastique in a randomized controlled trial that included 50 women with urodynamic SUI. A great majority of the injections (84%) were performed periuretherally in the Permacol group. At 6 months, 62.5% in the Permacol group were dry versus 37.5% in the Macroplastique group, but no statistical analysis was reported. Rates of adverse events were similar between both groups (68). Information on ongoing trials and current availability was unavailable from neither the manufacturer nor FDA Web sites.

FUTURE DIRECTIONS

Stem Cell Therapy

The development of regenerative medicine has enabled the application of autologous stem cells for SUI therapy. Multiple small series have been published. Most recently, a case series of 16 women who had sphincteric injection of muscle derived stem cells generated a cure/improved rate of 75% at 2 years of follow-up. There were no adverse events from either the deltoid muscle biopsy or from the injection (69). Cook MyoSite, a part of Cook Medical, has two active clinical trials underway with intrasphincteric injections of autologous muscle-derived cells (AMDCs) for the treatment of SUI. In unpublished pooled data with 12 months of follow-up from two phase I/II studies of AMDC at various doses ($n = 80$), injections appear safe with no reported adverse events and demonstrated significant improvements in UDI-6 and IIQ-7 scores at all doses. Additionally, efficacy data suggest a dose–response relationship with the higher dose groups demonstrating a higher percentage of patients with at least 50% reduction in stress leaks and pad weights. Although still considered experimental, stem cell therapy holds great promise and in the near future may very well be an additional option in therapy for the treatment of SUI (70).

CONCLUSIONS

Currently, injectable agents are best used for those who wish to avoid a surgical procedure or those who have problematic medical comorbidities that preclude them from undergoing surgical correction. Patients must be willing to accept an improvement rather than a cure of their SUI symptoms, and they must understand efficacy and duration of these agents are inferior to surgery, and follow-up injections may be required. Research continues the search for an effective, inert, nonmigratory, nonimmunogenic material that allows incorporation into native tissue, maintains its shape, and injects with ease. Currently, intraurethral bulking remains an art, as there is no exact measurement or amount of material used for each patient to achieve continence.

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CHAPTER 43 URETHRAL SLINGS

ALEX GOMELSKY

A form of “sling surgery” to treat female stress urinary incontinence (SUI) has existed for over a century. Despite the sequential implementation of various autologous tissues, allografts, xenografts, and synthetic materials, the sling procedure has traditionally been associated with significant complications and has been commonly reserved for the treatment of refractory SUI. However, owing to an improved understanding of SUI pathophysiology through the work of groups led by DeLancey (1), McGuire and Lytton (2), Blaivas and Jacobs (3), and Petros and Ulmsten (4), the sling has emerged over the last two decades as a reproducible, efficacious, and safe surgical option. Furthermore, novel materials, methods of suspension, and routes of placement have only served to decrease operative time and shorten convalescence, contributing to the sling becoming a contemporary gold standard for the surgical treatment of women with SUI. The focus of this chapter will be to describe the surgical technique behind the autologous rectus fascia bladder neck sling (BNS) and the retropubic and transobturator approach to the midurethral sling (MUS). Although there are several commercial options for approaches to the MUS, the operative procedure and anatomic landmarks are relatively standardized. Thus, I will describe only one example product for each type of approach for the retropubic and transobturator MUS. There will be no additional discussion of other materials placed at the bladder neck, and the single-incision minisling is, likewise, not discussed in this chapter. A brief review of surgical outcomes, comparative studies, and complications follows.

PATHOPHYSIOLOGY OF STRESS URINARY INCONTINENCE

It is universally accepted that continence during increases in intra-abdominal pressure depends on a complex interaction between urethral support, intrinsic urethral properties, the sphincter complex, and adjunct pelvic floor musculature. Two current theories build the case regarding the location of the anatomic weakness that contributes to SUI. In his “hammock hypothesis,” DeLancey (1) postulated that the urethra is supported by a hammock-like layer consisting of the vaginal wall and endopelvic fascia that is stabilized by lateral attachments to the levator ani and the arcus tendineus fascia pelvis. Along with the urethropelvic ligaments, these structures envelop the proximal urethra and aid in closure of the urethral lumen during increases in abdominal pressure. Slings placed at the bladder neck and proximal urethra aim to address this weakness. Conversely, in the “integral theory,” Petros and Ulmsten (4) proposed that the midurethra is the linchpin in the continence mechanism. The authors postulated that contraction of the pubococcygeus muscle during increases in abdominal pressure pulls the anterior vaginal wall forward and closes off the urethral lumen, a response that is contingent on an intact attachment between the pubourethral ligaments and anterior vaginal wall. Laxity in this midurethral fulcrum may subsequently lead to funneling of the urethra and urinary incontinence. The midurethra is the location for placement of the “tension-free” synthetic slings.

DIAGNOSIS

The American Urological Association (AUA) guidelines on SUI state that the minimum workup for an index patient presenting with SUI symptoms should include a history, pelvic examination, urinalysis and culture (if indicated), objective demonstration of incontinence (e.g., during cough stress testing), and assessment of postvoid residual urine (standard) (5). The index patient is an otherwise healthy female who has elected surgical therapy for the correction of SUI, may be untreated or previously surgically treated, and may have urethral hypermobility and/or intrinsic sphincter deficiency (ISD). The panel made a recommendation to add additional diagnostic studies to assess the integrity and function of the lower urinary tract: pad testing and/or voiding diary, urodynamics, cystoscopy, and imaging. Likewise, the panel made a recommendation to consider further testing for the following indications: inability to make a definitive diagnosis based on symptoms and/or the initial evaluation, concomitant overactive bladder symptoms, prior lower urinary tract surgery (including failed anti-incontinence procedures), known or suspected neurogenic bladder, negative cough stress test, abnormal urinalysis such as unexplained hematuria or pyuria, excessive residual urine volume, grade III or higher pelvic organ prolapse, and any evidence for dysfunctional voiding. Although there is some controversy regarding the role of urodynamics in cases of primary SUI, these diagnostic studies may be especially helpful in cases of mixed urinary incontinence, concomitant pelvic organ prolapse, incomplete emptying or neurogenic micturition dysfunction, and prior surgical failure (5).

ALTERNATIVE THERAPIES

Several nonsling options exist for the treatment of SUI. In women with mild or nonbothersome SUI, active treatment may be postponed until the incontinence impacts the patient’s quality of life. If active treatment is elected, pelvic floor muscle training with the potential addition of biofeedback may provide the woman significant improvement. Furthermore, urethral bulking therapy is another option that may provide benefit with minimal anesthetic requirement and procedural morbidity. Although the long-term benefit of this mode of therapy varies significantly in the literature, this remains a viable option in a select population. Finally, several additional, albeit infrequently performed, procedures are available for the surgical correction of SUI. Of these, transvaginal needle suspensions and suburethral plications have been associated with poor long-term outcomes and were not included in the most recent AUA SUI guidelines (5). Although the AUA Guidelines Panel found little new data regarding the efficacy of retropubic bladder neck suspensions (e.g., Burch or Marshall-Marchetti-Krantz), they concluded that there continues to be evidence for the efficacy of these procedures in selected patients (5).

INDICATIONS FOR SLING SURGERY

The introduction of the MUS can be viewed as a watershed event in the century of sling surgery. The novel procedure championed by Petros and Ulmsten was not only unique in its anatomic placement but also in its minimally invasive nature and reproducible outcomes. The transobturator MUS has gained further popularity because this approach avoids entry into the space of Retzius, thus potentially minimizing the serious viscus or neurovascular injuries that may occur from errant trocar placement during the retropubic approach (6). Owing to these advantages, the MUS has largely supplanted the rectus fascia BNS for most patients. One scenario where a BNS may continue to serve as the primary surgical option is in women who are undergoing a concomitant debridement of a MUS that has eroded into the vagina or urinary tract. Initially, it was also felt that ISD may be another relative indication for a BNS, as cure rates less than 20% were cited in these women who had a MUS (7). However, several authors have since noted that the retropubic MUS is associated with durable cure rates over the long term (8,9), and these exceed the cure rates seen with the transobturator approach in the ISD population (10,11). Ultimately, sling choice will be determined by the surgeon’s training and experience as well as a detailed informed consent discussion with the patient.

A few details remain once the decision to pursue operative therapy has been made. Although not all elements of vaginal prolapse require repair, consideration must be given to addressing prolapse at or distal to the hymenal ring, or symptomatic prolapse of a lesser degree, at the time of sling surgery. Doing so may minimize the possibility of SUI recurrence, urinary retention, or worsening prolapse.

A discussion of the risks, benefits, and options to sling surgery is key in obtaining informed consent. Risks may be intraoperative (bleeding, potentially requiring transfusion; injury to the bladder or urethra; hematoma formation), early postoperative (<30 days: urinary retention and other voiding symptoms; urinary tract infection; de novo, persistent, and/or worsened storage symptoms), and late postoperative (>30 days: urinary retention; need for urethrolysis or sling revision; dyspareunia; recurrent or de novo prolapse and SUI; de novo, persistent, and worsened storage symptoms). Harvest site complications, including seroma formation and infection, are relatively unique to rectus BNS. The risk of complications such as sling erosion and extrusion should also be mentioned. Although these sequelae are most commonly associated with synthetic mesh placement, any sling may erode into the urethra if placed under excessive tension.

SURGICAL TECHNIQUE

Preoperative Considerations

The following considerations apply for both BNS and MUS. A preoperative bowel regimen is typically not ordered for a sling-only procedure but can be considered for surgeries including a concomitant hysterectomy, vaginal vault suspension, or posterior compartment surgery. Prophylactic intravenous antibiotics are given within an hour of surgical “cut” time (first- or second-generation cephalosporin, gentamicin and clindamycin, or a fluoroquinolone) (12). Antithromboembolic hose and/or sequential compression devices are applied prior to induction of anesthesia. Regional or general anesthesia may be used for all slings, whereas local anesthetic protocols may be used for MUS. The ultimate choice of anesthesia is at the discretion of the surgeon, anesthesiologist, and patient. The pubic hair is clipped in the operating room. The patient is positioned in slightly exaggerated dorsal lithotomy position in Allen stirrups. Skin preparation is performed from below the umbilicus to the midthigh, and the vaginal canal is also prepped. After draping, an indwelling urethral catheter is placed to continuous drainage. A weighted vaginal speculum and Scott/Lone Star retractor may be of assistance in obtaining exposure. Liberal irrigation of the vaginal incision is performed throughout the case often with neomycin sulfate–polymyxin B sulfate solution or an alternative solution. Many surgeons will submerge the chosen sling material in antibiotic irrigation until ready to use. If a concomitant transvaginal procedure is planned to repair an anterior compartment prolapse, I prefer to make a separate midurethral incision for a MUS; however, I would use a single vaginal mucosal incision to address both the incontinence and prolapse if a rectus fascia BNS is planned. The AUA Guidelines Panel recommended that tensioning of any sling should not be performed until prolapse surgery is completed (5). Thus, it is my routine to perform all of the prolapse surgery first and conclude with the sling procedure.

Rectus Fascia Bladder Neck Sling

Fascial Harvest and Abdominal Incision

A low transverse incision two fingerbreadths above the superior edge of the pubic symphysis provides excellent exposure and cosmesis. The rectus fascia is exposed after incising the skin, subcutaneous fat, and Scarpa fascia. It is important not to excessively undermine the areolar tissue overlying the rectus fascia because this may increase the possibility of postoperative seroma. A strip of fascia measuring approximately 1.5 cm × 7 cm is excised and 2-0 polypropylene sutures are attached to each end (Fig. 43.1). The sling is soaked in antibiotic solution until the vaginal incision is prepared. The fascial rent is closed with continuous or interrupted no. 1 delayed absorbable suture. The skin and Scarpa layer are left open for the upcoming passage of sling sutures. Although there is no consensus regarding optimal sling length, it is widely accepted that the sling should be long enough to reach the space of Retzius and provide both suburethral and paraurethral support. Alternatively, autologous fascia lata harvested from the thigh is an alternative to rectus fascia. The use of this tissue may require patient repositioning and special instrumentation.

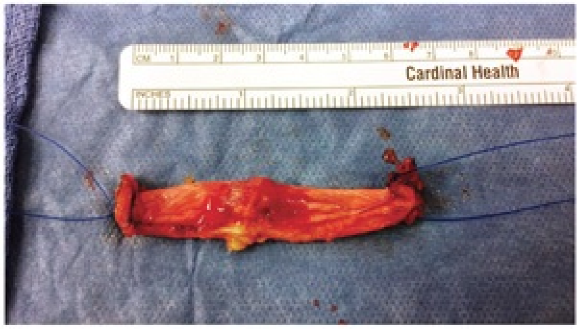


FIGURE 43.1 The rectus fascia graft is harvested and attached to 2-0 polypropylene sutures.

Vaginal Dissection

An inverted U incision provides excellent access to the bladder neck, with the apex of the U at the midurethra and the widely spaced legs of the U extending just proximal to the bladder neck.

Alternatively, a vertical midline incision may be used. The anterior vaginal wall may be infiltrated with normal saline or a hemostatic agent. The vaginal mucosa is dissected sharply off the underlying surface of the pubocervical and periurethral fascia, with lateral dissection proceeding up to the inferior edge of the pubic symphysis. The endopelvic fascia on each side of the urethra is perforated with Metzenbaum scissors and the space of Retzius is entered. The scissors should be aimed at the ipsilateral shoulder and remain just inferior to the pubic symphysis to minimize the possibility of bladder or vascular injury. Once the endopelvic fascia is perforated, paraurethral adhesions in the retropubic space may be released with an index finger.

Suture Passer Advancement

Any concomitant surgery to address anterior or apical compartment prolapse should be completed prior to suture passer advancement. Double-pronged needles (Cobb-Ragde) are used to pierce the rectus fascia approximately 2 cm lateral to the midline and remain immediately posterior to the pubic symphysis. A finger in the retropubic space from below may be used to guide the needle out of the vaginal incision on either side of the urethra (Fig. 43.2). Alternatively, a tonsil-tipped clamp, single-pronged (Stamey) or double-pronged (Raz) needle passer may be used. Ensuring that the bladder is completely empty prior to needle passage may minimize the possibility of bladder puncture.

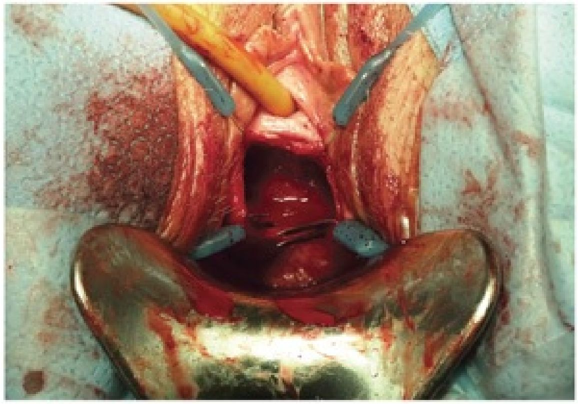


FIGURE 43.2 A double-headed needle is passed bilaterally through the rectus fascia and into the vaginal incision on either side of the urethra.

Cystoscopy

An ampule of indigo carmine dye is given intravenously. Ureteral integrity is confirmed on cystoscopy when blue-tinged urine effluxes from each ureteral orifice. A 70-degree lens may be helpful to visualize the dome and superolateral aspects of the bladder where penetration with passers is most likely to occur. It is vital to evacuate the air bubble and inspect that area carefully, as it may occasionally obscure the metal passers. It is also imperative to adequately visualize the entire path of the passer from the dome to the bladder neck and proximal urethra, as bladder integrity may be compromised anywhere along this path. If the bladder has been penetrated, the offending suture passer should be removed under direct vision, the bladder drained, and the needle should be passed again. Cystoscopy should be performed after each additional pass. Prolonged continuous catheter drainage should be considered to allow for additional bladder healing in the event of a bladder or urethral injury. The AUA Guidelines Panel concluded that intraoperative cystourethroscopy should be performed in all patients undergoing sling surgery (standard) (5).

Adjusting Sling Tension and Abdominal Wound Closure

The sling sutures are transferred into the abdominal incision, and the sling is then positioned over the bladder neck and the sling edges are anchored to the periurethral fascia with 4-0 delayed absorbable suture (Fig. 43.3). After irrigating with antibiotic solution, the vaginal incision is closed with 2-0 delayed absorbable suture.

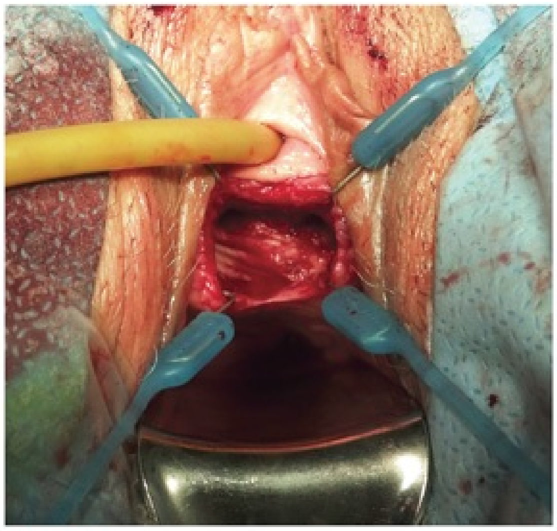


FIGURE 43.3 The sling is positioned flat at the bladder neck and anchored to the periurethral fascia to keep it from slipping during the tensioning process. The vaginal incision is then closed.

Prior to suture tensioning, the patient's legs are lowered to a comfortable lithotomy position and all retractors and speculums are removed. One pair of sutures is tied to the contralateral pair over the rectus fascia under no tension. Typically, the assistant will insert their index and middle fingers as a spacer between the suture knot and the rectus fascia. After two knots, the knot is gently clamped with a rubber shod and tension is tested by removing the urethral catheter and inserting a cystoscope sheath into the bladder. If there is no hitch in passing the sheath into the bladder, then the sling tension is adequate, and additional knots may be now added to the sutures. If there is a hitch, then the knot should be undone and more laxity given to the sling. This is repeated until the cystoscope sheath is passed into the bladder without a hitch.

The abdominal wound is irrigated with antibiotic solution and Scarpa fascia is reapproximated with interrupted 3-0 delayed absorbable sutures. The skin is closed with subcuticular 4-0 delayed absorbable sutures. The vagina is carefully packed with gauze impregnated with estrogen cream, Betadine, or saline.

Top-Down Retropubic Midurethral Sling

As for the BNS, the anterior vaginal wall may be infiltrated with a hemostatic solution or with normal saline for the purposes of hydrodissection. The mucosa is then incised in the midline for approximately 2 cm, with the incision beginning 1 cm proximal to the urethral meatus and proceeding in the direction of the proximal urethra (Fig. 43.4). Allis clamps placed on the edges of the incision may facilitate retraction and exposure. Using Metzenbaum scissors, lateral vaginal flaps are developed until the inferior edge of the pubic symphysis can be easily palpated on either side of the urethra (Fig. 43.5). For the SPARC sling (American Medical Systems, Inc, Minnetonka, Minnesota), two stab incisions are made in the suprapubic skin (Fig. 43.6). Each is approximately two fingerbreadths (or 2 to 3 cm) lateral to the midline and overlies the superior edge of the pubic symphysis. The skin may be infiltrated with 1% lidocaine or 0.25% Marcaine for additional local anesthesia. The SPARC trocars are then advanced through each suprapubic incision and pierce the rectus fascia in a perpendicular direction (Fig. 43.7). Each trocar is then guided toward the ipsilateral vaginal dissection taking care to remain behind and in contact with the pubic symphysis at all times.

Passing the trocar just underneath the symphysis is facilitated by rotating the passing hand cephalad and displacing the handle of the needle posteromedially. An index finger of the nonpassing hand is inserted into the ipsilateral area of vaginal dissection to simultaneously protect the urethra from puncture and to “bring out” the passer (Fig. 43.8). As with BNS procedures, complete bladder emptying may decrease the chance of bladder puncture from trocar passage. If care is taken to follow these steps, the possibility of inadvertent bladder puncture can be minimized even in the obese patient or those with who have failed previous retropubic surgeries.

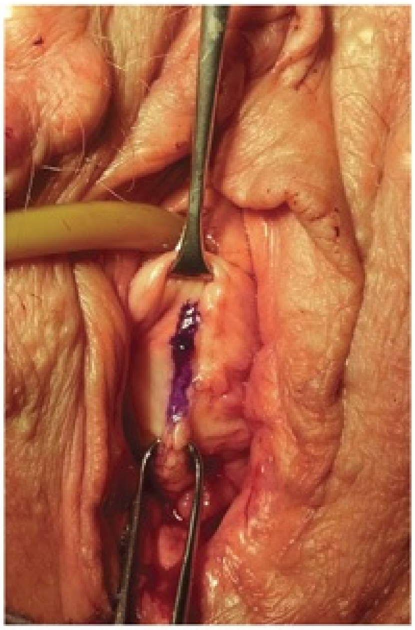
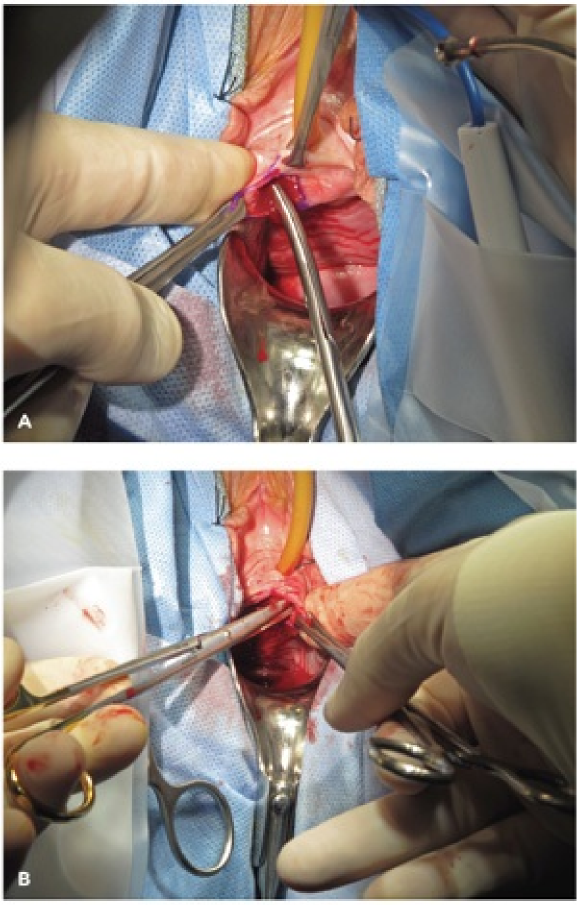


FIGURE 43.4 The mucosal incision begins 1 cm proximal to the urethral meatus and proceeds for approximately 2 cm proximally.



FIGURES 43.5 **A and B:** Lateral vaginal flaps are developed until the inferior edge of the pubic symphysis can be easily palpated on either side of the urethra.

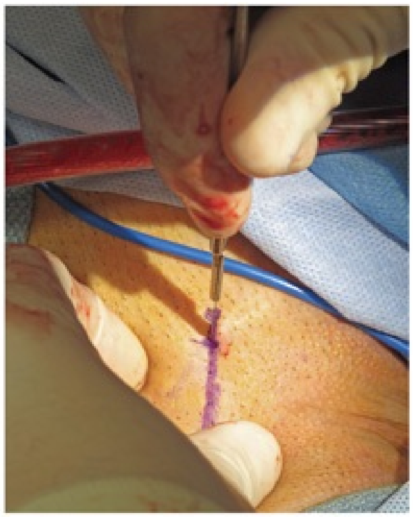


FIGURE 43.6 Two stab incisions are made in the suprapubic skin over the superior edge of the pubic symphysis and each approximately two fingerbreadths lateral to the midline.

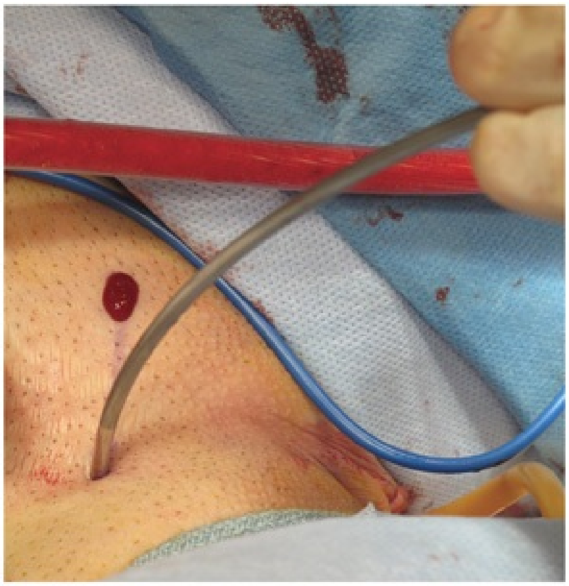


FIGURE 43.7 The SPARC trocars pierce the skin and rectus fascia in a perpendicular direction and remain behind and in contact with the pubic symphysis at all times.

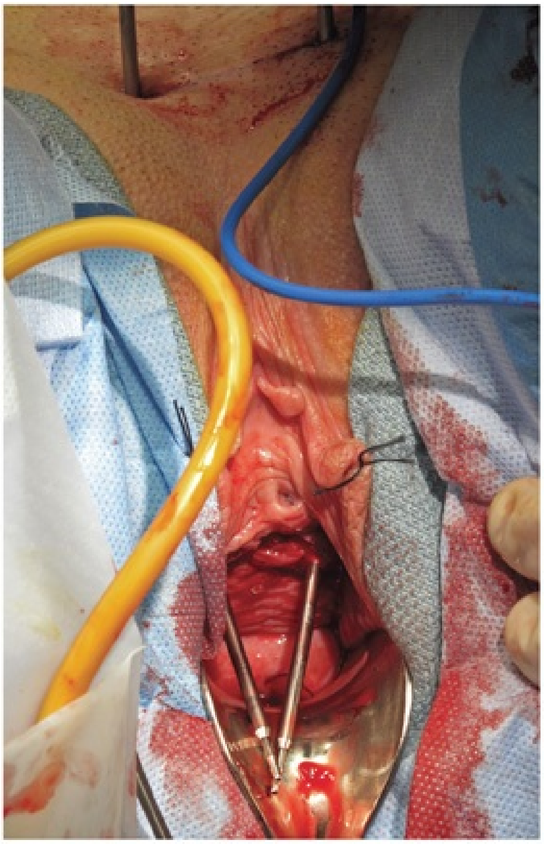


FIGURE 43.8 Both trocars have been guided through the vaginal incision on either side of the urethra.

Cystoscopy is performed after both needles have been advanced and the details of the cystoscopic evaluation are summarized in the section on rectus fascia BNS. If a bladder puncture occurs after trocar passage, the offending trocar is removed and repassed after bladder decompression (Fig. 43.9). Cystoscopy should be performed after each new pass. If a urethral injury occurs during dissection or trocar passage, the injury should be repaired and the procedure terminated until sufficient healing has occurred (5).

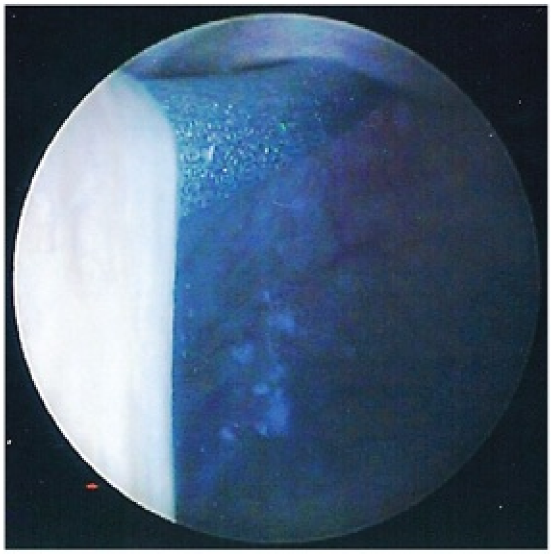


FIGURE 43.9 A trocar puncture is seen at the patient's right superolateral side of the bladder. The trocar should be removed, bladder drained, and the trocar should be repassed slightly laterally. Repeat cystoscopy should be performed to rule out repeat bladder puncture.

Each end of the sling is connected firmly to the trocars and the sling ends are advanced through the abdominal incisions by removing the trocars (Fig. 43.10). Care is taken to position the sling in a flat position under the midurethra and ensure that no twisting has occurred. The plastic sheath over the sling is cut off below the blue mark, as the mesh and sheath are fused above the mark, and an edge of the sheath is grasped with a clamp on each side. Tensioning technique varies greatly between surgeons, and no single technique has been determined to be superior. Common spacing devices between the sling and the urethra include scissors, a Kelly clamp, or Hegar dilators (Fig. 43.11). The common thread of any tensioning technique is to ensure placement of the sling without tension in a flat position at the midurethra. Once the sling is tensioned to the satisfaction of the surgeon, the sheath is removed and redundant sling ends are cut at the surface of the suprapubic skin. The SPARC has an interwoven tensioning suture which may aid in adjusting tension after the sheath has been removed. I will typically lower the legs to a comfortable lithotomy position and recheck tension-free placement before incision closure. If the procedure is performed under local anesthesia, the bladder may be filled and a cough or Valsalva maneuver may be performed on the table; however, it is important to note that many women will not have visible leakage in the lithotomy position. The suprapubic incisions can be reapproximated with benzoin or Dermabond, but if excessive bleeding is encountered at the skin edges, it may be controlled with cautery or with subcuticular 4-0 delayed absorbable sutures. The vaginal incision is closed with a 2-0 delayed absorbable running suture, and vaginal packing may be applied at the surgeon’s preference.

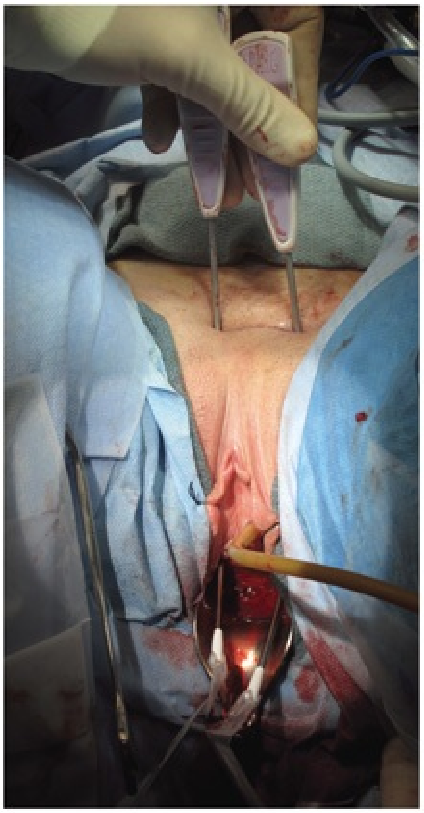


FIGURE 43.10 The sling is connected firmly to the trocars and the ends are advanced through the abdominal incisions by withdrawing the trocars.

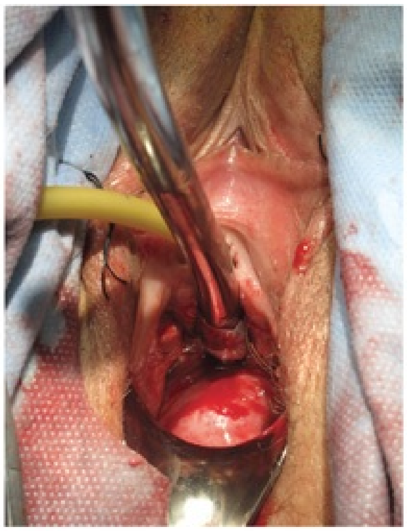


FIGURE 43.11 A Hegar dilator is placed between the sling and the urethra to ensure tension-free placement of the sling.

Bottom-Up Retropubic Midurethral Sling

The operative steps for placement of a tension-free vaginal tape (TVT, Ethicon) are similar to the top-down sling (SPARC) through the steps on vaginal dissection and suprapubic incisions. A catheter guide is placed through the urethral catheter after complete bladder drainage, and the guided catheter is used to tent up the contralateral bladder dome to minimize ipsilateral bladder puncture. The TVT trocar is then placed in the vaginal incision and aimed at the ipsilateral scapula, beginning to curve the trocar superiorly after advancing it beyond the inferior edge of the pubic symphysis. The trocar is then brought out through the ipsilateral suprapubic incision, and the procedure is repeated on the contralateral side. Cystoscopy, sling tensioning, and closure of the incisions is performed as previously described.

Outside-In Transobturator Midurethral Sling

For a Monarc Subfascial Hammock (American Medical Systems, Inc, Minnetonka, Minnesota), a vertical midline incision is made as described previously for the retropubic MUS. The vaginal epithelium is then dissected laterally toward the inferior edge of the inferior pubic ramus. The incision should allow the tip of the surgeon's index finger to extend under the inferior pubic ramus (Fig. 43.12). A 5- to 10-mm vertical skin incision is made at the intersection of a horizontal line 2 cm superior to the urethral meatus and 2 cm lateral to the folds of each thigh (Fig. 43.13A). This location often corresponds to the level of the clitoris and is located at the notch along the internal edge of the inferior pubic ramus and adductor longus tendon. Hyperflexion of the hips may be helpful in identifying the adductor longus tendon, and the skin incisions typically correspond to the location of the thumb when the tendon is pinched between the thumb and index finger (Fig. 43.13B). A helical passer is initially inserted perpendicular to the skin and then rotated medially under the inferior pubic ramus to meet the surgeon's contralateral index finger in the vaginal incision (Fig. 43.14). The finger is used for guidance as well as for protecting the urethra from inadvertent puncture.

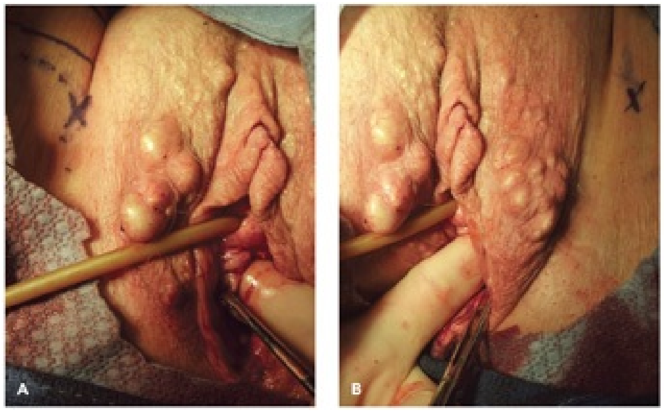


FIGURE 43.12 **A and B:** The optimal depth of lateral dissection allows the tip of the surgeon's index finger to extend under the inferior pubic ramus. In each figure, an Allis clamp is on the ipsilateral edge of the vaginal mucosa and the blue *X* marks the site of the planned incision over the transobturator skin.

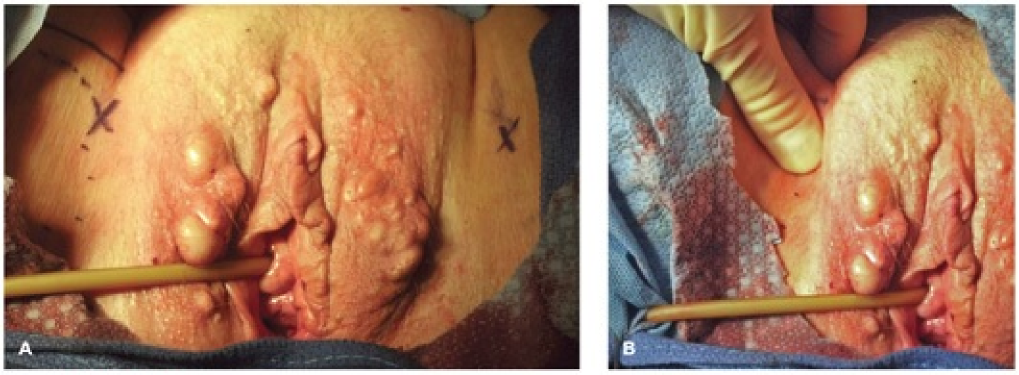


FIGURE 43.13 **A and B:** Skin incisions often correspond to the level of the clitoris and the notch along the internal edge of the inferior pubic ramus and adductor longus tendon. The location of the thumb when the tendon is pinched between the thumb and index finger is another useful landmark for the skin incisions.

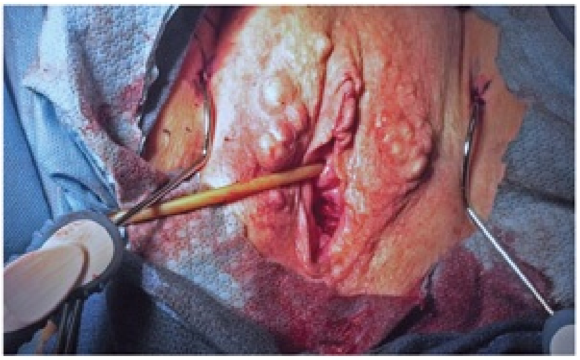


FIGURE 43.14 Helical passers are advanced perpendicular to the skin and then rotated medially under the inferior pubic ramus to exit lateral to the urethra.

Although the incidence of bladder and urethral puncture is extremely low during the transobturator approach, it is my practice to perform cystoscopy after trocar advancement on all women undergoing this procedure. As opposed to the retropubic sling, the most likely areas of bladder penetration are inferolateral (5 and 7 o'clock positions). As with other sling procedures and approaches, any trocar penetrating the bladder should be removed and repositioned with cystoscopy confirming safe placement after each additional pass.

The mesh sheath may be snapped onto the passer once the tip is visible in the vaginal incision and then withdrawn out of the skin incision (Fig. 43.15). Tensioning and wound closure is accomplished as previously described (Fig. 43.16).

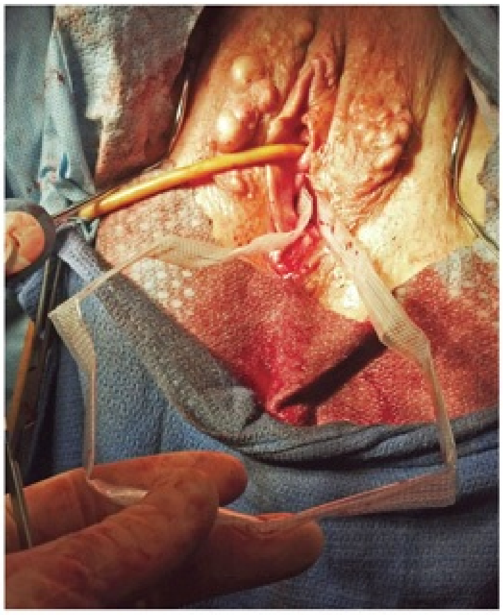


FIGURE 43.15 The mesh sheath may be snapped onto the passer once the tip is visible in the vaginal incision and then withdrawn out of the skin incision.

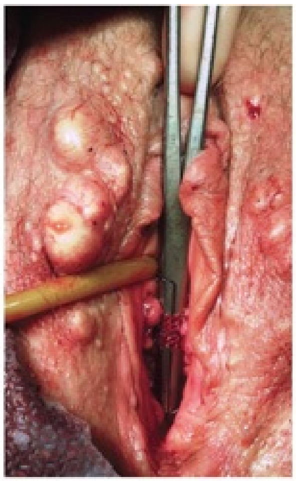


FIGURE 43.16 Tension-free positioning may be optimized with a spacer, such as a Kelly clamp, between the sling and the urethra.

Inside-Out Transobturator Midurethral Sling

For the tension-free vaginal tape obturator procedure (TVT-O, Ethicon), vaginal incision and lateral dissection are similar to the outside-in approach. The obturator membrane is sharply perforated with Metzenbaum scissors, indicated by a loss of resistance to dissection. An included winged metal guide is then inserted into the obturator membrane at the same angle as the scissors. If additional length is necessary, the winged guide can be extended from 6 to 7 cm in length. A similar incision is made in the skin overlying the obturator foramen, and a helical passer is advanced into the groove of the winged guide until the obturator membrane is entered. The guide is removed and the passer handle is rotated until it is perpendicular to the floor and the tip of the passer emerges from the obturator incision. The passer is removed and the mesh is clamped. The procedure is repeated on the opposite side. Cystoscopy, sling tensioning, and wound closure is accomplished as previously described.

Postoperative Considerations

Women undergoing concomitant prolapse surgery are typically admitted for overnight observation;

however, women undergoing MUS only are often discharged the same day. Although overnight observation is common for those women undergoing rectus fascia BNS, select patients may be discharged the same day. Vaginal packing is removed and a voiding trial may be performed the following morning. If postvoid residual volumes are elevated, an indwelling catheter is replaced and an outpatient voiding trial is performed in the next few days. Alternatively, the patient may be preoperatively instructed in clean intermittent catheterization to begin at home. A longer period of continuous bladder drainage may be considered if the bladder was penetrated with a suture passer during the procedure. All patients are discharged with analgesics and a stool softener.

OUTCOMES

The surgical success rates of rectus fascia BNS is typically high in the short term. An evaluation of several retrospective studies of the rectus fascia sling reveals early "cure" rates ranging from 72.9% to 94% (13–17). However, cure rates may wane with follow-up exceeding 4 years (17). In long-term follow-up of patients who were randomized to Burch colposuspension or rectus fascia BNS, urinary continence rates decreased during postoperative years 2 to 7 from 52% to 27% in the sling group (18). The long-term success after the retropubic MUS in several retrospective studies appears to be stable, with both subjective and objective cure criteria exceeding 75% at 10 to 17 years of follow-up (19–21); however, some authors have noted a decline in cure rates with longer periods of follow-up (22). Likewise, the subjective and objective outcomes after the transobturator MUS at 5 years of follow-up remain durable (23). It is important to note that comparing "cure" rates between various studies is challenging due to variations in the definition of success, outcome criteria, length of follow-up, inclusion and exclusion criteria, incidence of concomitant surgery, and reporting of perioperative complications. In a study by Rapp and Kobashi (24), 39% of their patients were completely dry, whereas an additional 33% claimed to have less than one leakage episode per week. Additionally, 52% used no pads, whereas 27% used 1 to 3 liners per day. When subjective satisfaction was assessed using a 10-point scale, 34% of women scored their level a 10 while 24% scored it a 9.

In their recent meta-analysis, Novara et al. (25) identified several randomized controlled trials (RCTs) comparing autologous pubovaginal sling to TVT. TVT and autologous slings were associated with similar overall continence rates (OR 0.80; 95% CI, OR 0.51 to 1.26; $P = .35$) and subjective continence rates (OR 1.28; 95% CI, OR 0.74 to 2.23; $P = .38$). The Cochrane review echoed these findings in 2009 (26). The review by Novara et al. (25) evaluated 24 studies that compared retropubic MUS to transobturator MUS and concluded that the retropubic MUS was associated with higher objective cure rates (OR 0.8; 95% CI, 0.65 to 0.99; $P = .04$); however, the subjective cure rates were similar (25). Additional RCTs published since these reviews have predominantly supported the aforementioned findings (27).

COMPLICATIONS

As with reports of surgical outcomes, detailed accounts of complications after sling surgery are often incomplete and inconsistent. In a summary of complications between a contemporary cohort of women randomized to rectus BNS and Burch, there was no significant difference in the percentage of women who had serious adverse events (13% versus 10%, $P = .20$) (28). However, surgical procedures to reduce voiding symptoms or improve urinary retention were performed exclusively in the sling group, in which 19 patients underwent 20 such procedures. Adverse events were also more common in the rectus BNS group (63% versus 47%, $P < .001$), and this difference was due primarily to urinary tract infections (UTIs). When UTIs were excluded, the rates of adverse events were similar in the two groups. The incidence of bladder injury during BNS surgery is less than 1% and complications related to the harvest site approach 15% (13,28–30). The rate of bladder puncture with the retropubic MUS approaches 10% and is extremely rare during the transobturator MUS (8). All sling procedures are associated with potential voiding difficulty or persistent or worsened storage symptoms. Thus, patients should be counseled preoperatively about the possibility of sling revision for extrusion, obstruction, or refractory storage symptoms.

In a meta-analysis encompassing 33 RCTs, Novara et al. concluded that the TVT and BNS were associated with similar complication rates (31). In comparing the top-down to the bottom-up approach, SPARC was associated with higher rates of voiding lower urinary tract symptoms (LUTS) (P = .02) and reoperations (P = .04) when compared with the TVT. The occurrence of bladder perforations (P = .007), pelvic hematoma (P = .03), and storage LUTS (P = .01) were significantly less common in patients treated by transobturator MUS when compared with women undergoing retropubic MUS.

CONCLUSIONS

Several conclusions can be drawn regarding the slings described in this chapter. First, all of the available options have been shown to be effective in improving or curing SUI in women. Second, all slings are not created equal and each has its own risk to benefit profile. Although the rectus BNS employs autologous tissue and incites a minimal inflammatory response, it requires fascial harvest that may be associated with incisional complications and additional convalescence. The MUS procedures are less invasive and the outcomes are durable; however, trocar-related injuries and the potential for vaginal extrusion due to the synthetic material may be unique to the MUS procedure. Third, reports of success vary significantly based on the definitions used and should be evaluated with “a grain of salt.” Finally, the decision to pursue sling surgery, as well as the choice of sling and approach, should be tailored to the individual patient and should take into account the patient’s wishes and the surgeon’s experience. A detailed discussion of specific risks, benefits, and options to sling surgery is essential to obtaining preoperative informed consent and cannot be overemphasized.

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CHAPTER 44 ■ ABDOMINAL RETROPUBIC APPROACHES FOR FEMALE INCONTINENCE

LESLIE M. RICKEY

Urinary incontinence (UI) is common, with approximately 30% of women reporting any incontinence; about 25% to 50% of these cases are estimated to be stress urinary incontinence (SUI) (1–3). In addition, the number of women seeking care for UI is increasing. Office visits for UI more than doubled from 815,832 visits in 1992 to 1,932,768 visits in 2000 (4). A recent analysis of population growth and future demand for care concluded that consults for pelvic floor disorders will increase by 45% from 2000 to 2030 (5). In terms of surgical management, one out of nine women will have surgery for a pelvic floor disorder in their lifetime, and this number represents only a subset of women who have the condition (6). About one-third of the surgeries were for SUI alone, and another 20% of surgeries were performed for combined SUI and pelvic organ prolapse (POP).

Although the exact mechanism that leads to SUI is not known, proposed theories include loss of proximal urethral support, or the “hammock” theory, and intrinsic deficiency of the external urethral sphincter. Surgical procedures are directed toward correction of the deficiency, either reestablishing support of the proximal urethral or improving urethral closure. The suburethral sling procedure can be performed using autologous fascia (rectus fascia or fascia lata) or synthetic material. The sling procedures are covered in other chapters.

Urethral position depends on anterior vaginal wall support. Retropubic colposuspension, or urethropexy, aims to improve the support of the vesicourethral junction by elevating the periurethral tissue toward the pubic bone, thus restoring the proper anatomy. The procedure is believed to treat incontinence by providing improved resistance to increases in intra-abdominal pressure, resulting in more effective urethral compression. The Marshall-Marchetti-Krantz (MMK) procedure involves suturing the periurethral tissue at the level of the bladder neck directly to the periosteum of the pubic symphysis. Burch, a gynecologist, modified this technique by altering the suspension laterally to the iliopectineal line or Cooper’s ligament. The Burch technique was further modified by Tanagho, a urologist, to include a suture bridge instead of direct apposition of the anterior vaginal wall to Cooper’s ligament. The Burch urethropexy has traditionally been performed via a small Pfannenstiel incision, but the laparoscopic approach has been used as well.

The MMK is largely a historical procedure as the Burch appears to be slightly more efficacious. In addition, the complication of osteitis pubis is specific to the MMK approach due to the placement of suture directly into the periosteum. Although the Burch urethropexy may be regarded as an outdated procedure as well, it is still a reasonable option for a woman desiring an incontinence procedure, particularly if she is undergoing a concomitant abdominal surgery. In addition, as will be discussed later in the chapter, it is indicated for an asymptomatic, stress-continent woman undergoing an abdominal sacrocolpopexy for prolapse.

DIAGNOSIS

A thorough and detailed patient history should elicit whether the patient has stress incontinence, urge incontinence, or mixed incontinence. It is important to ascertain a history of previous incontinence or pelvic surgeries, as this may affect surgical decision making. Prolapse symptoms should also be queried, as almost two-thirds of women with SUI have coexisting POP (7), and additional procedures may be necessary at the time of the incontinence surgery. Finally, it is prudent for physicians performing pelvic surgery to inquire about whether the patient’s Pap screening is up to date.

The physical examination should include a bimanual and speculum examination to assess the vaginal tissue and vaginal support and to rule out any pelvic masses. A positive empty supine cough stress test is highly predictive of urodynamic stress incontinence (8). Urethral hypermobility is typically confirmed before considering a Burch urethropexy. Traditional teaching has used the cotton-tipped swab test to measure urethral hypermobility. A cotton-tipped swab is inserted transurethrally to the proximal urethra, and the patient is asked to maximally Valsalva. A deflection of >30 degrees from the resting angle during Valsalva is considered to reflect urethral hypermobility. The surgeon should inspect the lower abdominal wall for scars indicative of previous pelvic surgery and correlate with the patient's surgical history.

If the patient relates SUI symptoms and desires surgical treatment, many surgeons choose to perform urodynamics (UDS) to confirm the diagnosis. It is believed that the Burch is not as effective in women with "intrinsic sphincter deficiency," typically defined by indirect measures of urethral function, including leak point pressure <60 mm Hg or urethral closure pressure of 20 mm Hg or less. However, a randomized trial comparing Burch to sling in women with low urethral closure pressures (20 cm H_2O or less) did not show a difference in subjective success between the two procedures at a mean 5 years of follow-up (84% versus 93%, respectively, $P = .47$) (9). Although the study was not powered to detect small differences between the treatment groups, the findings still demonstrate that the Burch procedure can be effective in women with low urethral closure pressures. Valsalva leak point pressure (VLPP) has not been shown to be a significant predictor of success after the Burch procedure (10). In addition, a retrospective review of women who underwent a Burch urethropexy with preoperative VLPPs of <60 cm H_2O showed an objective success rate of 91.7%, indicating that a low VLPP is not necessarily predictive of Burch failure (11). Direct measurement of striated urethral sphincter physiology using electromyography suggested that women with better innervation of their urethral sphincters were more likely to be cured by the Burch urethropexy (12). In summary, there are no UDS parameters clearly predictive of Burch success or failure. Therefore, traditional urodynamic testing does not seem to aid in the surgeon's decision of which incontinence procedure to perform. However, the study can provide helpful information about the coexistence of detrusor overactivity, clarify confusing symptomatology, and confirm diagnoses in patients who have undergone previous incontinence surgeries.

INDICATIONS FOR SURGERY

The main indication for an incontinence procedure is the presence of symptomatic SUI that adversely affects the woman's quality of life. The patient should also have the sign of transurethral loss of urine with a cough stress test or during formal urodynamic testing. Additionally, the patient must be sufficiently healthy to undergo regional or general anesthesia, be able to be placed in dorsal lithotomy position, and have a habitus that allows a suprapubic incision. There appears to be a risk of worsening POP after a Burch procedure (13–15); therefore, a Burch urethropexy probably should not be performed as a solitary procedure if there is significant apical descent. Lack of urethral hypermobility and a previously failed retropubic approach would be considered indications for a suburethral sling by most pelvic surgeons.

A Burch urethropexy is also appropriate for an asymptomatic woman (without SUI) undergoing a sacrocolpopexy for POP. A randomized controlled trial showed that performing a concomitant Burch urethropexy at the time of abdominal sacrocolpopexy resulted in a decrease of new-onset postoperative SUI from 40% to 20% in stress-continent women (16).

ALTERNATIVE THERAPY

Conservative therapies for SUI may involve use of pessaries or physical therapy for pelvic floor muscle (PFM) rehabilitation. In women successfully fitted with a pessary for UI, rates of continued use and satisfaction range from 16% to 59% at 1 year (17,18). PFM physical therapy includes both strengthening and instruction on timing of activation of PFMs to avoid leakage. A Cochrane review in 2007 supported that PFM training should be included in first-line conservative management for women with UI (19). In women with SUI who participated in a course of PFM exercise, 44% to 56% of patients were satisfied with symptom improvement and desired no further treatment (20,21).

SURGICAL TECHNIQUE

Open Burch Urethropexy

The patient is placed in the low dorsal lithotomy position and the vagina and abdomen are prepped and draped for combined access. A Foley catheter is placed and a Pfannenstiel incision is made. Dissection of the space of Retzius is performed (Fig. 44.1). The first and second fingers of the surgeon’s nondominant hand are placed in the vagina, with one finger on each side of the urethral catheter. The bladder is retracted medially so that the perivaginal tissue lateral to the vesicourethral junction is exposed. Using the vaginal finger as a guide, a peanut sponge can be used to carefully sweep away the overlying fat until the glistening white perivaginal “fascia” is visualized. Care must be used as vaginal and pelvic veins are often encountered in this area. Palpation of the Foley balloon will help delineate the vesicourethral junction. Two figure-of-eight sutures are placed in the periurethral vaginal tissue, one at the vesicourethral junction and another more distally at the level of the midurethra. Avoid placing the sutures through any fatty tissue. Placement of the sutures into the vagina is aided by elevation of the anterior vaginal wall using the hand in the vagina (Fig. 44.2A). The vaginal finger should be used as a guide to ensure that the sutures are sufficiently lateral to the urethra. The suture bite should encompass vaginal tissue without perforating the vaginal epithelium (Fig. 44.2B). The procedure is repeated on the other side. A total of four permanent, nonabsorbable sutures such as no. 0 or no. 1 polyester (Ethibond) or polytetrafluoroethylene (Gore-Tex) sutures are placed (two on each side; Fig. 44.3A). Cooper’s ligament is identified and any overlying tissue is gently swept off using a peanut sponge.

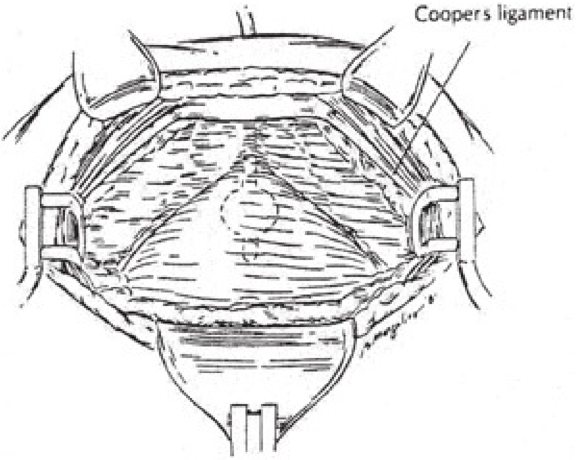

FIGURE 44.1 Retropubic space showing the bladder neck, Foley balloon, and Cooper’s ligament.

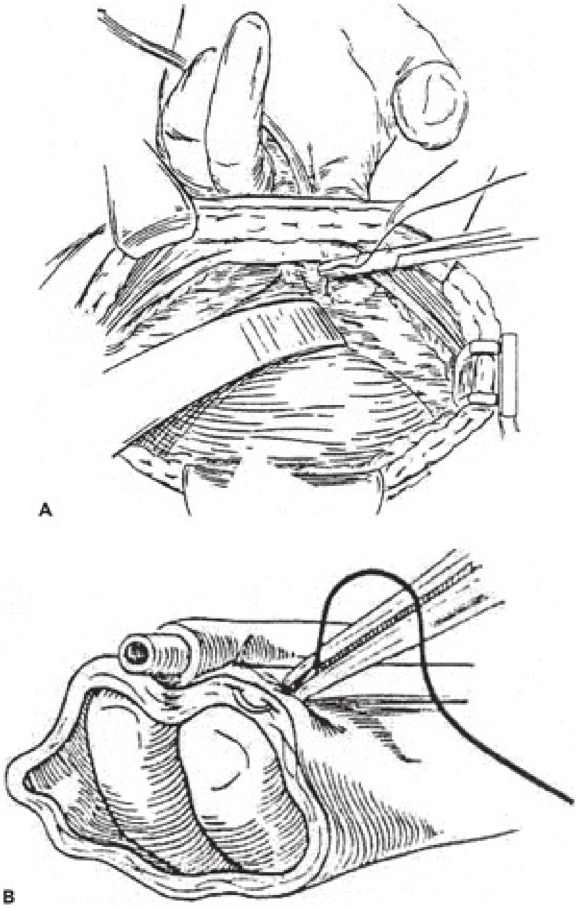

FIGURE 44.2 **A:** The first suture at the level of the vesicourethral junction. The surgeon's finger in the vagina helps guide the suture lateral to the urinary tract. **B:** The finger in the vagina also helps exclude the suture from the vaginal epithelium.

The sutures are then placed through Cooper's ligament on the respective sides (Fig. 44.3B). Note that the sutures are tied off the midline. The proximal sutures will be placed slightly lateral to the more distal midurethral sutures. The obturator vessels and nerve pass through the obturator fascia; this obturator "notch" is the lateral limit for suture placement into Cooper's ligament and should be avoided. The assistant ties the sutures down while the operator's fingers remain in the vagina to ensure the proper degree of suspension. The operator should feel that the anterior wall is slightly lifted without overcorrection of the urethrovesical junction. It is imperative that the sutures are tied such that there is distance between Cooper's ligament and the vaginal tissue (Fig. 44.3B) seen as a suture bridge of approximately 2 cm. This prevents overcompression of the urethra, which can cause obstruction. The placement of these sutures and how tightly they are tied differ from the initial description of Burch in which the sutures were tied down with complete approximation of the perivaginal tissue onto Cooper's ligament. After tying the sutures, cystoscopy is performed to ensure that the sutures did not perforate the bladder and that the ureters are patent. Methylene blue can be used to help identify efflux of urine from the ureteral orifices.

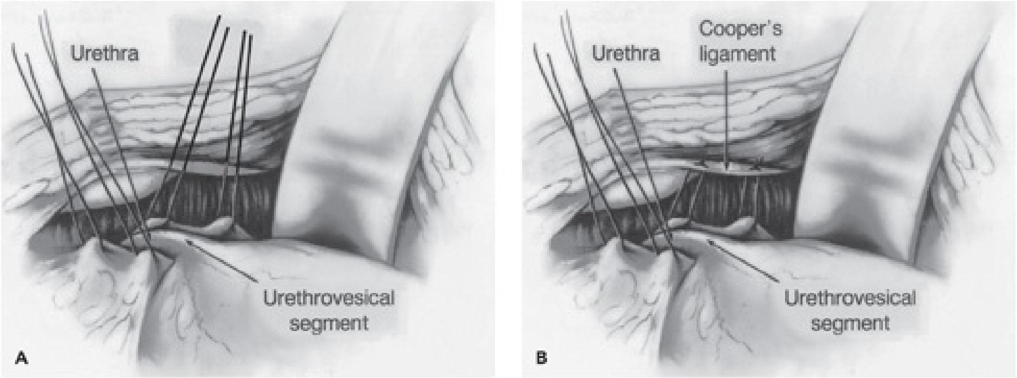

FIGURE 44.3 **A:** A total of four sutures are placed in the periurethral tissue. **B:** The two right-sided sutures are passed through Cooper's ligament and tied; note that there is a gap between the vaginal tissue and Cooper's ligament, creating a suture bridge.

Laparoscopic Burch Urethropexy

Apart from the incisions, the laparoscopic Burch is performed in an identical manner to the open Burch procedure. There are a variety of port placement strategies described. A common approach is to place a 10-mm laparoscopic port at the umbilicus and two 5-mm ports in the lower lateral abdominal wall, approximately two fingerbreadths superior and medial to the anterior superior iliac spine. An additional suprapubic port is sometimes used. As in the open approach, cystoscopy should be performed at the end of the procedure to exclude intravesical suture and ensure ureteral patency. The laparoscopic procedure is covered in more detail in the chapter dedicated to laparoscopic surgery for UI.

OUTCOMES

Results

A recent Cochrane review showed overall cure rates between 69% and 88% for open retropubic colposuspension (22). A randomized controlled trial comparing Burch to suburethral sling showed stress-specific success of 49% (compared to 66% for the sling group) at 2 years using a very strict definition of success (23). However, there was also a lower rate of adverse events in the Burch group. The overall patient satisfaction was slightly lower in the Burch group (78% versus 86%, $P = .02$). When the patients were followed out to 5 years, continence rates continued to decrease, and surgical retreatment was significantly higher in the Burch group (26% versus 2% in the sling group; $P < .001$). Patient satisfaction remained higher in the pubovaginal sling group (83% versus 73%, $P = .04$) (24). Preoperative variables that predicted recurrent UI included increasing age, prior UI surgery, menopausal status, and urge incontinence symptoms (25).

Another randomized trial comparing Burch to tension-free vaginal tape (TVT) revealed 63% of women reporting cure after the Burch (versus 70% in TVT group, $P = .54$) at 5 years, but overall, 90% of women who had undergone colposuspension were satisfied or very satisfied with the results of surgery (14). Using a negative 1-hour pad test (<1 g change in weight) for definition of cure, and using pad test data from the last available follow-up visit for missing data, the cure rates were computed as 69% for colposuspension versus 75% for TVT ($P = .28$). Finally, a systematic review and meta-analysis of retropubic procedures for the treatment of SUI showed a significantly higher overall cure rate for midurethral slings over Burch urethropexy, although subjective continence rates were similar. Bladder perforation was more common after midurethral sling; however, other complications, including retropubic hematoma and urinary tract infections, were similar (26) in a randomized controlled trial comparing laparoscopic to open Burch, there were no significant differences seen at 24 months in patient-reported cure of stress incontinence (66%), although the study was not powered to detect a difference of <20% (27). There was not a significant difference in perioperative complications. Out of six cases of suture penetration into the bladder, five occurred in the laparoscopic group, but this difference did not reach statistical significance ($P = .11$). Mean operating time was less in the open group (87 versus 42 minutes, $P < .0001$), and blood loss was less in the laparoscopic group (126 versus 170 mL, $P = .03$). There was no difference in length of hospital stay, but the average return to normal activities was 5 days less in the laparoscopic group (24.6 versus 19.7 days, $P = .01$). A meta-analysis of studies comparing laparoscopic versus open Burch had similar findings of longer operating times, marginally less blood loss, decreased hospital stay, and faster return to normal activity in the laparoscopic group (28). There was not a significant difference in subjective or objective cure rates up to 2 years postoperatively.

Finally, a randomized trial comparing laparoscopic Burch to TVT with a median follow-up of 65 months concluded that the two procedures have similar long-term efficacy (29). Although only 52% of subjects in the TVT group and 43% in the Burch group reported no urine leakage under any circumstances, bothersome urine leakage was present in only 8% and 11%, respectively ($P = .26$), and overall patient satisfaction rates were similar as well (79% versus 88%). Operating time was less in the TVT group, but there was no difference in blood loss or hospital stay. In terms of bladder injury, there were two cystotomies in the TVT group and two patients with bladder sutures detected intraoperatively in the laparoscopic Burch group.

COMPLICATIONS

Delayed bladder emptying was seen in 2% of patients after undergoing a Burch urethropexy in a large multicenter study, but no additional procedures were required for urinary retention (23). These patients may require temporary intermittent self-catheterization. Occasionally, the periurethral sutures must be released transvaginally to relieve the urethral obstruction if there is not adequate bladder emptying at 4 to 6 weeks postoperatively. New-onset urge UI occurs in 3% to 4% of patients, and 5% report de novo urgency (14,23). In a patient with significant postoperative urgency and frequency, urinary retention, and urinary tract infection should be ruled out: As many as 30% of patients may develop a urinary tract infection in the postoperative period (23).

Ureteral injuries occur in <1% of patients. Bladder injury is more common, with incidental cystotomy rates of 2% to 4%, usually due to suture passage into the bladder. A recent study showed that 2 of 329 (0.6%) patients sustained a ureteral injury and 10 out of 329 (3.3%) had an incidental cystotomy when undergoing a Burch urethropexy (23). A cystoscopy at the time of surgery can aid in identifying intravesical sutures, and ureteral patency can be confirmed as well.

Approximately 8% to 13% of women are found to have vaginal vault or uterine prolapse during the follow-up period after Burch (14,15,30). The clinical significance of the prolapse has been unclear; however, a randomized controlled trial comparing Burch to TVT showed that surgery for prolapse was more common after the Burch colposuspension (7.5% versus 1.8%, $P = .025$) (14). Therefore, a sling may be a more appropriate choice for a woman desiring an incontinence procedure who has asymptomatic prolapse with apical descent of several centimeters or more.

CONCLUSION

A Burch urethropexy should be considered for a woman desiring an incontinence procedure, particularly if she is undergoing a concomitant abdominal surgery, or for a stress-continent woman undergoing an abdominal sacrocolpopexy.

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CHAPTER 45 THE ARTIFICIAL URINARY SPHINCTER

ANGELO E. GOUSSE, HARI S. G. R. TUNUGUNTLA, NEAL PATEL, AND IZAK FAIENA

INTRODUCTION AND EPIDEMIOLOGY

Normal lower urinary tract function is critical in maintaining urinary continence at low bladder pressure. Up to 16 to 20 million Americans have some type of urinary incontinence with potential major psychosocial consequences. Urinary incontinence is prevalent in men, although the overall numbers are lower than in women. The Epidemiology of Lower Urinary Tract Symptoms (EpiLUTS) study examined rates of urinary incontinence in both men and women in the United States, United Kingdom, and Sweden (1). Prevalence of any urinary incontinence was as high as 46% for men and 68% for women reporting urinary incontinence. However, this included various forms of urinary symptoms in addition to incontinence. When categorized by type, 5.6% of men reported urgency urinary incontinence only, 0.8% stress urinary incontinence only, 1.4% mixed urinary incontinence, 6.3% had urgency urinary incontinence and another form of urinary incontinence, and 1.2% had stress and another form of urinary incontinence.

Etiology for urinary incontinence includes neurologic disorders, iatrogenic following surgery on the lower urinary tract (e.g., radical prostatectomy and transurethral resection of the prostate), and bladder dysfunction. Urinary incontinence secondary to intrinsic sphincter dysfunction can potentially be cured by artificial urinary sphincter (AUS), an implantable prosthetic device consisting of a pressure-regulating balloon (PRB), a cuff and a pump mechanism (Figs. 45.1 to 45.3). There are several choices of PRB including those with a preset pressure of 51 to 60, 61 to 70, or 71 to 80 cm H_2O. Selection of the PRB is based on the location of the cuff. Although 61 to 70 cm H_2O pressure balloon is the most commonly used PRB, a higher pressure (71 to 80 cm H_2O) is sometimes used for recurrent stress urinary incontinence and when a bladder neck cuff is used. The cuff is available in sizes ranging from 3.5 to 5.5 cm, the selection of which depends on its location at the bulbar urethra versus bladder neck. The choice of cuff size needs a subtle calculation sometimes in that an additional 2 to 3 mm may be added to the measured urethral circumference to account for the inaccuracy in measuring the actual circumference at the insertion site. A smaller cuff becomes necessary in patients with recurrent incontinence following cuff atrophy. A 5.0-cm and sometimes 5.5-cm cuff may be used if it is inserted at bladder neck. The pump has a built-in deactivation button, manual pump, and delayed refill resistor. An activated cuff remains open for 2 to 4 minutes as fluid leaves the cuff, only to slowly return through the refill resistor in the pump, restoring continence. Transfer of fluid and the resultant transfer of pressure to the cuff is prevented by the deactivation button of the pump when this feature is used, thus leaving the device temporarily nonfunctional and the patient incontinent.

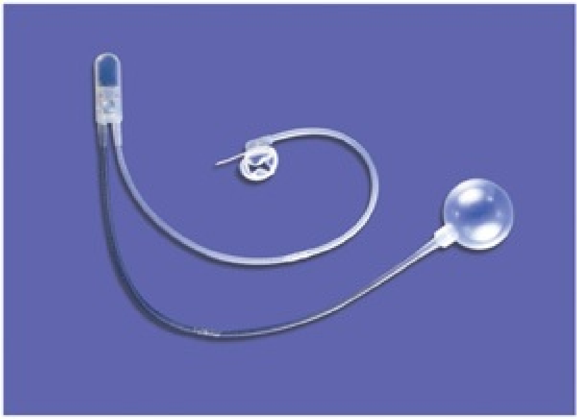

FIGURE 45.1 AUS with single cuff.

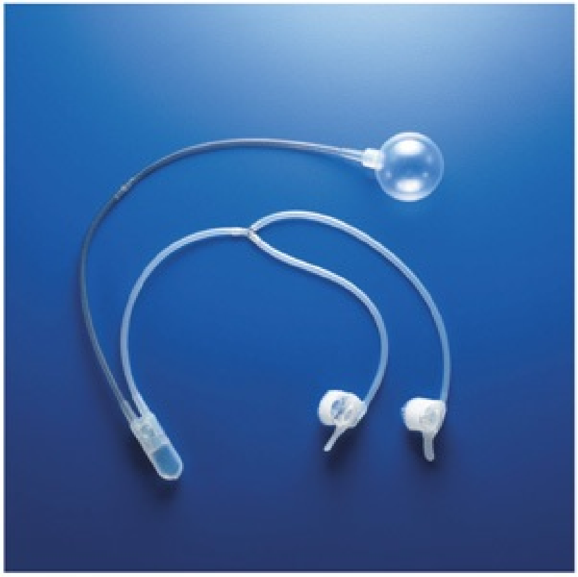

FIGURE 45.2 AUS with double cuff.

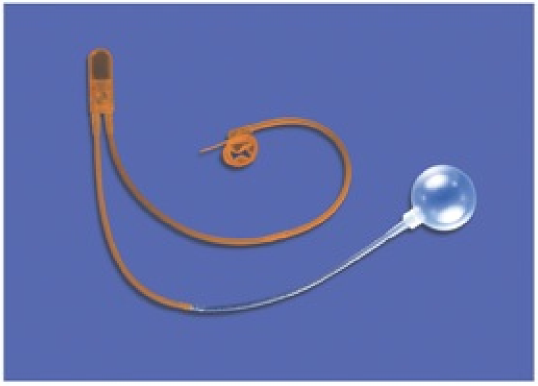

FIGURE 45.3 AUS with InhibiZone-coated cuff and control pump.

Since its first implantation by Brantley Scott in 1972 (2), the original model underwent several technical modifications and advances resulting in the current AUS implant. Notable advances in design include the narrow-backed cuff (1987) (3) to limit urethral erosion and color-coded kink-resistant tubing assuring secure device assembly and function. It was recently reported that learning curve for AUS placement was found to be approximately 25 cases based on complications and reoperation rates (4).

DIAGNOSIS

Identifying the source and type of the incontinence is the first step in determining the need for an AUS. Diagnosis of the etiology of incontinence can be determined using multichannel urodynamic testing such as videourodynamic studies. Such studies assess the intrinsic sphincter function, bladder capacity, and detrusor compliance as well as evaluate for detrusor overactivity and leak point pressures. This evaluation is especially important in patients with neurogenic etiologies because AUS placement in some of these patients can have potentially detrimental long-term effects to renal function.

Along with urodynamic evaluation, cystoscopic examination must be performed to evaluate the quality and health of the urethral tissue throughout, and especially at the level where an AUS is to be placed whether it is at the bladder neck or bulbar urethra. Most importantly, urethral stricture must be ruled out with cystoscopy.

A thorough physical exam should be performed. Specifically, a neurologic assessment is essential in determining patient eligibility for AUS placement. Traditionally, the pump is placed in the right hemiscrotum in a right-handed patient and on the left side in a left-handed patient. During physical exam, it is of paramount importance to confirm that the patient has the required manual dexterity, pincer grip, and finger strength necessary for the day-to-day manipulation of the pump to achieve satisfactory voiding. Evaluation of the genitalia is also important in identifying integumentary and microbial issues that may prevent placement of AUS. Sites of planned incisions must be examined carefully to assess for viability and integrity of the skin because this is important in operative planning and placement eligibility.

INDICATIONS FOR SURGERY

Indications for Artificial Urinary Sphincter Placement

Postprostatectomy incontinence due to intrinsic sphincter dysfunction is the most common indication for an AUS. Other indications include posterior urethral trauma leading to incompetent sphincter; persistent female incontinence refractory to all other incontinence therapies; and congenital abnormalities leading to persistent incontinence such as exstrophy-epispadias complex, spina bifida, and various other genitourinary abnormalities.

Contraindications for Artificial Urinary Sphincter Placement

As mentioned earlier, a key physical exam assessment is the patient’s neurologic status. AUS is absolutely contraindicated in patients with physical and/or mental disability whose conditions are severe enough to render them noncompliant and/or unreliable regarding management and use of the device.

Relative contraindications include female patients with prior history of pelvic radiation because they are at higher risk for erosion (both urethral and vaginal). Also included are patients with progressive neuromuscular disorders who may initially be deemed fit to use the device properly in the short term but will likely be unable to use the device in the long term. Lastly, patients with uncontrolled detrusor overactivity, noncompliant bladders, and/or small bladder capacity are also relatively contraindicated.

ALTERNATIVE THERAPIES

Given lack of sphincter function, aside from AUS placement, the patient may consider urethral bulking agents, bladder neck closure, male urethral sling placement, and/or urinary diversion. Selection of urethral sling versus AUS based on the measured Valsalva leak point pressure (e.g., AUS for very low leak point pressures of <40 cm H_2O pressure and sling for patients with moderate leak point pressures of 50 to 70 cm H_2O pressure) is a contentious issue. However, male urethral sling may be an option in patients with cystoscopically documented residual sphincter function, partial coaptation of the sphincteric urethra, and absence of any sectoral defects in the external urethral sphincter (Table 45.1).

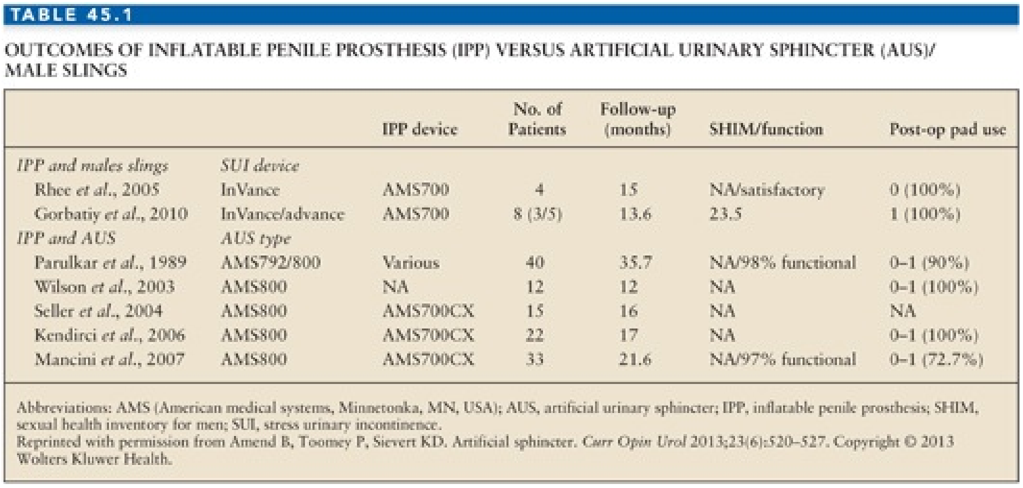

TABLE 45.1

OUTCOMES OF INFLATABLE PENILE PROSTHESIS (IPP) VERSUS ARTIFICIAL URINARY SPHINCTER (AUS)/ MALE SLINGS

		IPP device	No. of Patients	Follow-up (months)	SHIM/function	Post-op pad use
IPP and males slings	*SUI device*					
Rhee *et al.*, 2005	InVance	AMS700	4	15	NA/satisfactory	0 (100%)
Gorbatiy *et al.*, 2010	InVance/advance	AMS700	8 (3/5)	13.6	23.5	1 (100%)
IPP and AUS	*AUS type*					
Parulkar *et al.*, 1989	AMS792/800	Various	40	35.7	NA/98% functional	0–1 (90%)
Wilson *et al.*, 2003	AMS800	NA	12	12	NA	0–1 (100%)
Seller *et al.*, 2004	AMS800	AMS700CX	15	16	NA	NA
Kendirci *et al.*, 2006	AMS800	AMS700CX	22	17	NA	0–1 (100%)
Mancini *et al.*, 2007	AMS800	AMS700CX	33	21.6	NA/97% functional	0–1 (72.7%)

Abbreviations: AMS (American medical systems, Minnetonka, MN, USA); AUS, artificial urinary sphincter; IPP, inflatable penile prosthesis; SHIM, sexual health inventory for men; SUI, stress urinary incontinence.
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SURGICAL TECHNIQUE

Preoperative Preparation

Infection of an implanted AUS device can have long-term detrimental effects for the patient. Therefore, it is important to be prudent regarding potentially modifiable preoperative and postoperative factors which may affect risk of infection. In a recent contemporary series, *Staphylococcus aureus* was the most common causative agent for AUS infection (5).

Preventive strategies must be employed to ensure the patient has the best chance for an infection-free outcome. Patients with urinary tract infections must be treated prior to surgery. Skin infections or irritation and breakdown in the area of the genitalia and planned incision sites must be addressed, and preventive measures must be taken in the perioperative period to prevent recurrences during the tissue healing process. If the genital skin involvement is secondary to urinary leakage, preoperative indwelling urethral or suprapubic catheter placement facilitates healing of the skin. Because catheters are potential sources for urinary tract infections, it is recommended removing catheter placed for this reason about 1 week prior to AUS implantation. If the patient had a catheter or intermittently catheterizes, prophylactic antibiotics may be considered starting a few days prior to the procedure.

Preoperative antibiotics that cover both aerobic and anaerobic organisms should be given approximately 1 hour before surgery or at time of induction. Antibiotic choice must have broad enough coverage for both skin and genitourinary flora.

Patient preparation also includes on-table shaving; patients must be instructed not to shave prior to arriving to the hospital on the day of the procedure. Shaving immediately prior to the start of the operation will reduce the chance of infection.

A recent randomized controlled trial evaluating the efficacy of chlorhexidine versus povidone-iodine–based antimicrobial scrubs in patients undergoing genitourinary prosthesis placement found that chlorhexidine prep was superior to povidone-iodine prep regarding positive postpreparation cultures of 8% versus 32%, respectively. They also concluded that there was no significant difference in urethral or genital skin irritation among the two skin preps. Chlorhexidine required a 2-minute prep time versus 5-minute prep time for povidone-iodine. Overall, this study found chlorhexidine to be a superior agent (6). The authors did not report any significant difference in the incidence of clinical complications between the two groups.

After anesthesia is induced and the patient has been shaved, the patient should be positioned in a dorsal lithotomy position and after being prepped should be draped in a such way to allow the surgeon access to both the perineum, genitalia, and suprapubic and lower abdominal area. Next, a 16Fr urethral catheter should be placed. Betadine mixed with normal saline is instilled in the urethra prior to the insertion of the urethral catheter because this is colonized in some patients.

ARTIFICIAL URINARY SPHINCTER PLACEMENT IN MEN

Perineal Cuff Placement

In men, proximal bulbar urethral cuff placement is optimal. For cuff placement around the bulbous urethra, a midline perineal incision should be made over the bulbar urethra. The incision should allow for dissection and exposure of approximately 2 cm length of urethra (Fig. 45.4). Great care must be taken in handling the corpus spongiosum, and every measure should be taken to prevent inadvertent entry into the urethral lumen. Electrocautery should be avoided in controlling bleeding associated with injuries to corpus spongiosum, which should be repaired with absorbable (4-0) suture instead.

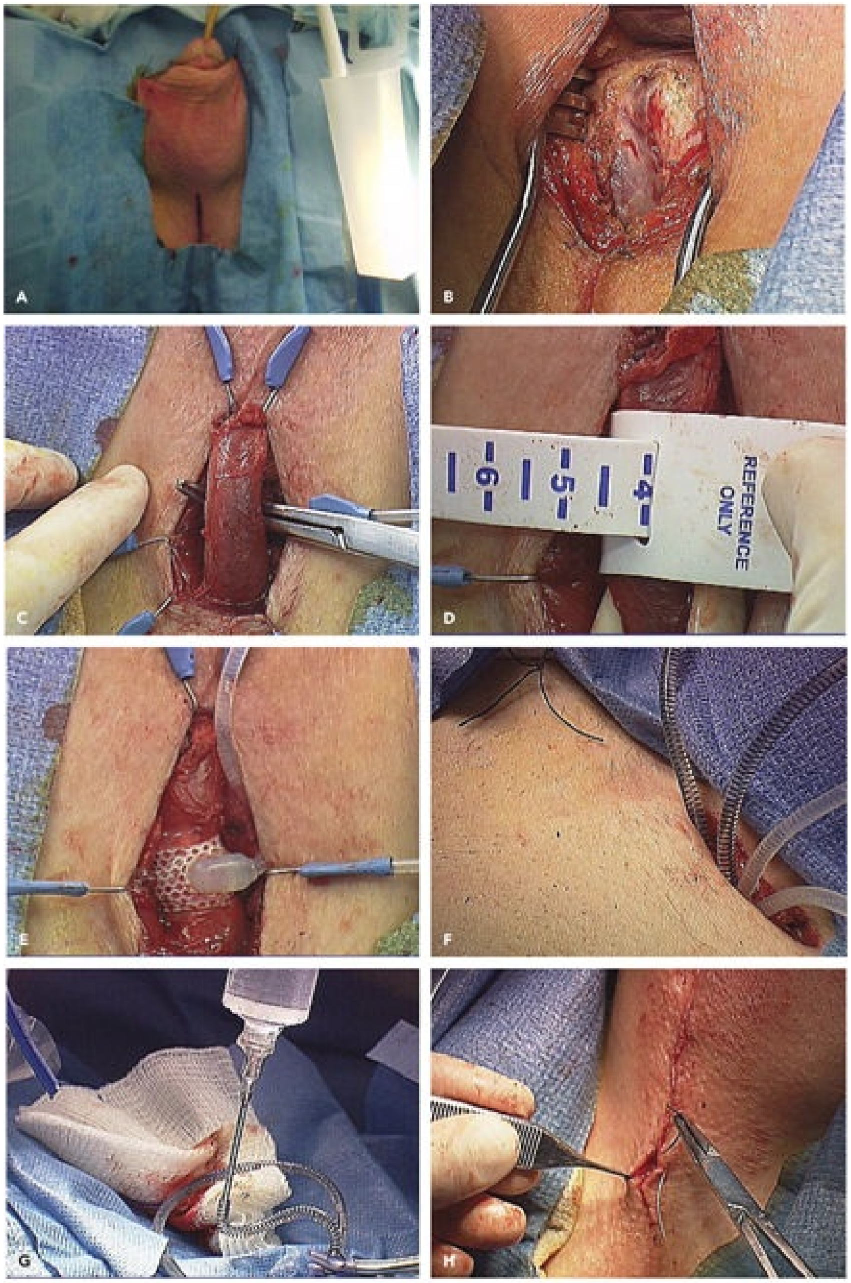

FIGURE 45.4 Various steps depicting perineal cuff placement in men. **A:** Perineal skin incision. **B:** Exposure of corpus spongiosum of the bulbar urethra after incising bulbospongiosus muscle. **C:** Circumferential mobilization of bulbar urethra. **D:** Measurement of the circumference of the bulbar urethra to select the appropriate cuff size. **E:** Appropriate size cuff placed around the proximal bulbar urethra. **F:** Clear and black tubing of the AMS 800. **G:** Filling of the reservoir with the "filling solution". **H:** Subcuticular closure of the perineal skin incision.

The urethral mobilization should be carried out circumferentially by freeing the attachments of the dorsal aspect of the urethra from its adjacently associated corpora. Once the urethra is freely mobilized, the circumference can be accurately determined using the sizer/measuring tool provided in the AUS surgical kit. When placing the sphincter, the cuff size should be such that it is neither too tight nor too loose. One of the hints to ensure determine appropriate cuff size is that one should be able to easily insert the closed jaws of a right-angle clamp between the urethra and the sizer/cuff. It is important to select the cuff about 2 to 3 mm longer than the measured size to prevent a tight fitting cuff over the urethra, thereby preventing possible erosion. Usually, the most common size for a man undergoing a bulbar urethra AUS implant is 4.0 to 4.5 cm. More recently, 3.5-cm cuffs are starting to gain favor for both primary and revision AUS placement (7).

After the cuff is placed, a 4- to 5-cm incision is made 2 to 3 cm above and just lateral to the pubic symphysis. This will be the planned reservoir (PRB) site. A transverse incision is then made in the fascia followed by blunt dissection to develop a space for the reservoir (PRB) between the transversalis fascia and the retropubic space. The PRB is then placed in the space developed and inflated to 23 to 25 mL. Intraperitoneal placement of the PRB is not recommended because the PRB is functional only in the relatively closed retropubic space (personal communication, December 2014, American Medical Systems, Minnetonka, Minnesota). The type of the PRB chosen (61 to 70 cm H_2O pressure versus 51 to 60 cm H_2O pressure) depends on the indication for AUS placement. PRB with a higher pressure (71 to 80 cm H_2O) may be used with a bladder neck cuff. If AUS placement is for postprostatectomy incontinence, then a 61- to 70-cm H_2O pressure PRB is acceptable. If the patient has any condition that may increase the chance of atrophy or erosion (such as prior radiation), a lower pressure PRB (51 to 60 cm of H_2O pressure) is indicated. The tubing from the cuff will need to be passed into the suprapubic incision to be connected to the reservoir.

Next, the control pump is placed in the subdartos pouch that is developed by spreading the ring clamp. The pump is placed in the right hemiscrotum in a right-handed person and vice versa. It is placed in the most anterior and dependent portion of the scrotum superficial enough with the deactivation button easily palpable. A path for the pump tubing is developed superiorly from the suprapubic incision into the perineal incision using a long clamp. It is important to secure the pump through the scrotal skin with a Babcock clamp to allow for optimal pump positioning while providing adequate tubing length until the end of the procedure.

Once all the tubing has been passed, excess tubing should be cut away and the remaining tubing should be connected using the connectors provided in the AUS accessory kit. Once all the tubing has been connected, the system should be cycled to test pump function. During the test, the urethral catheter should be removed, and urethroscopy should be used to visualize the cuff to assess for degree of occlusion of the activated cuff. Once the surgeon is satisfied, the cuff should be deactivated and remain deactivated for 4 to 6 weeks to allow for proper healing. Each layer of the wound is closed with absorbable sutures. The urethral catheter need not be reinserted unless there is suspicion regarding inadequate bladder emptying. The patient should be made aware that their incontinence will persist until the AUS is activated after an appropriate healing period. Patients can usually be discharged home 2 to 3 hours after surgery or on the first postoperative day with a 5- to7-day course of an oral antibiotic. The device is traditionally activated 6 weeks following implantation.

Transcorporeal Cuff Placement

This approach is usually reserved for patients who have had prior urethral erosion and/or an anatomically suboptimal urethra secondary to prior infected AUS or severe atrophy. Raj et al. (8) noted that comorbidities such as hypertension, coronary artery disease, and prior radiation predisposed the patient to a higher chance of erosion. Given that a more proximal placement of an AUS is sometimes not feasible, a more distal approach has been evaluated but not without its own set of challenges. Wall thickness of the corpus spongiosum of the urethra becomes an issue, as it becomes thinner distal to the bulbar urethra, putting the urethra at a higher risk of erosion.

Guralnick et al. (9) have reported success with transcorporeal cuff placement by using the tunica albuginea to bulk the urethral wall, thereby minimizing erosion and allowing for distal cuff placement in patients undergoing revision surgery.

Technique

A 2- to 3-cm portion of urethra distal to the bulbar urethra is selected, and under urethroscopic guidance, the skin incision made overlying the urethra and corporal bodies allowing for adequate exposure (Fig. 45.5). Next, 2.5-cm incisions are made bilaterally in the tunica albuginea of both corpora cavernosa after perforating the septum between the corpora cavernosa, creating a flap of corporal tissue over the dorsal roof of the urethra (Fig. 45.6A). This provides enough urethral buttress/protection to allow a larger than otherwise cuff to be placed, thus decreasing chance of erosion (Fig. 45.6B). The cuff is then inserted followed by repair of the corporotomies (Fig. 45.6C). It is important to note that there is a risk of decreased erectile function in potent men undergoing this procedure (9).

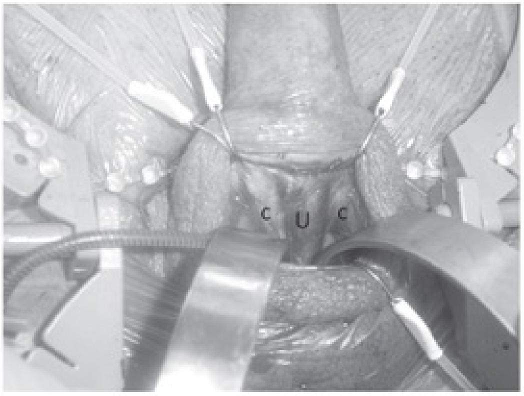

FIGURE 45.5 Initial dissection of the urethra, showing the urethra (*U*) and the corpora cavernosa (*C*) on either side.

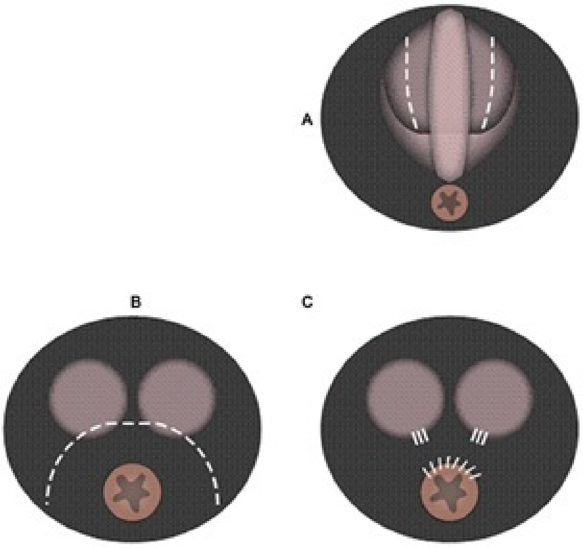

FIGURE 45.6 **A:** Transcorporeal cuff placement: Vertical corporotomies are made bilaterally. **B:** The tunica over the corpora is left attached to the urethra for extra support of urethral tissues. **C:** The remaining tunica albuginea is reconstituted behind the position of the cuff. The *broken lines* indicate incisions in the tunica albuginea of the right and left corpora cavernosa. (Adapted with permission from Guralnick ML, Miller E, Toh KL, et al. Transcorporal artificial urinary sphincter cuff placement in cases requiring revision for erosion and urethral atrophy. *J Urol* 2002;167(5):2075–2079. Copyright © 2002 American Urological Association, Inc. Published by Elsevier Inc. All rights reserved.)

A more recent study by Wiedemann et al. (10) reviewed the existing literature along with their own cohort to better assess the role of transcorporeal cuff placement in the salvage setting to further elucidate outcomes with respect to erectile function and continence. They concluded that this method continues to be a useful alternative in the setting of urethral atrophy and/or erosion after prior AUS placement. Among six patients (*n* = 23) who had good preoperative erectile function and were sexually active, four had similar International Index of Erecticle Function (IIEF-5) score as before surgery with preservation of erectile function.

Transverse Scrotal Incision for Artificial Urinary Sphincter Placement

Traditional techniques usually use two incisions for placement of an AUS, one incision in the perineum and the other in the suprapubic area. Wilson et al. (11) introduced the concept of a single incision or transscrotal technique in 2003. This allowed all components of the AUS to be placed through a single incision with the patient in lithotomy or supine position (Fig. 45.7). A 3- to 4-cm transverse high scrotal incision is made near the penoscrotal junction. Self-retaining hook retractors can be used to optimize the exposure securing the base and shaft of the penis along with the glans superiorly on the anterior abdomen in mild stretch.

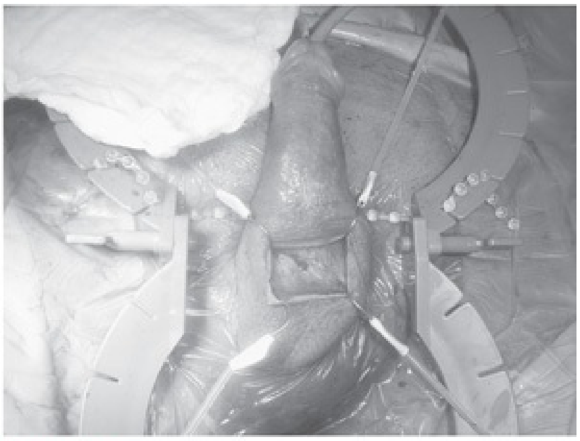

FIGURE 45.7 Transverse scrotal incision for placement of AUS with Lone Star ring retractor in place.

In this approach, the bulbar urethra is the target. To expose the bulbar urethra, both corpora cavernosa must both first be exposed proximally so that the attachment between the corpora spongiosum and the scrotal septum is clearly defined. Next, this attachment is sharply divided, and a pediatric Deaver retractor may be used to facilitate additional exposure. Next, the dissection is carried down to the level of the most proximal bulbar urethra. The bulbar urethra is then circumferentially freed for 2 to 3 cm around the targeted cuff position (Fig. 45.8). The cuff is then placed followed by blunt dissection to the level of the external ring. A pair of Metzenbaum scissors is used to perforate the transversalis fascia, and blunt dissection is used to develop the space for the PRB (Fig. 45.9). The reservoir is then placed and filled with 23 to 25 mL of filling solution (Fig. 45.10). A subdartos pouch is developed to place the control pump (Fig. 45.11). Excess tubing is excised, and connections between the reservoir, cuff, and pump are made using the connection kit provided by the AUS kit. The AUS is then cycled and tested as previously described.

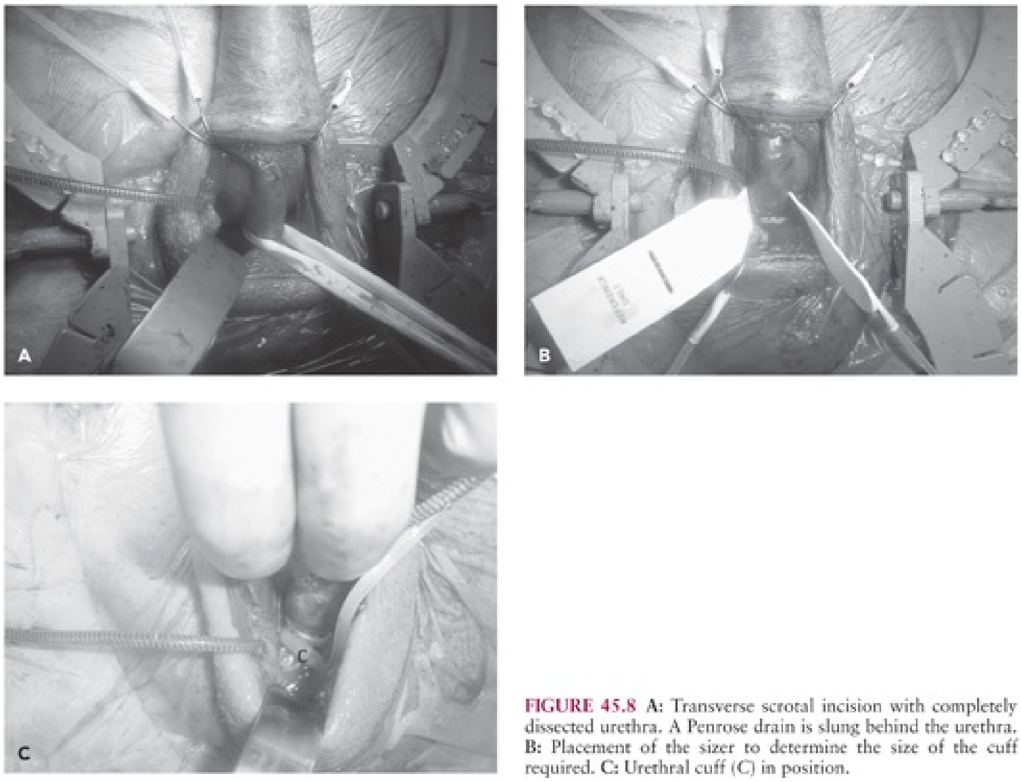

FIGURE 45.8 A: Transverse scrotal incision with completely dissected urethra. A Penrose drain is slung behind the urethra. B: Placement of the sizer to determine the size of the cuff required. C: Urethral cuff (C) in position.

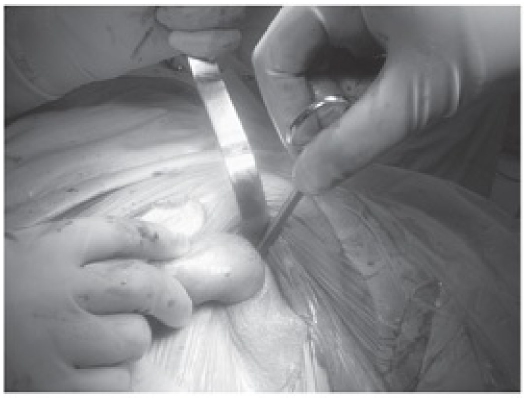

FIGURE 45.9 Through the same transverse scrotal incision, Metzenbaum scissors are used to perforate the transversalis fascia and develop the pocket for placement of the reservoir.

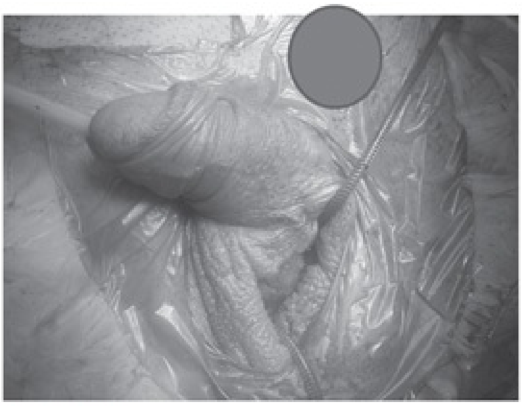

FIGURE 45.10 The reservoir is in position in the space of Retzius. The tubing connecting to the reservoir can be seen caudally. The *circle* represents the position of the reservoir.

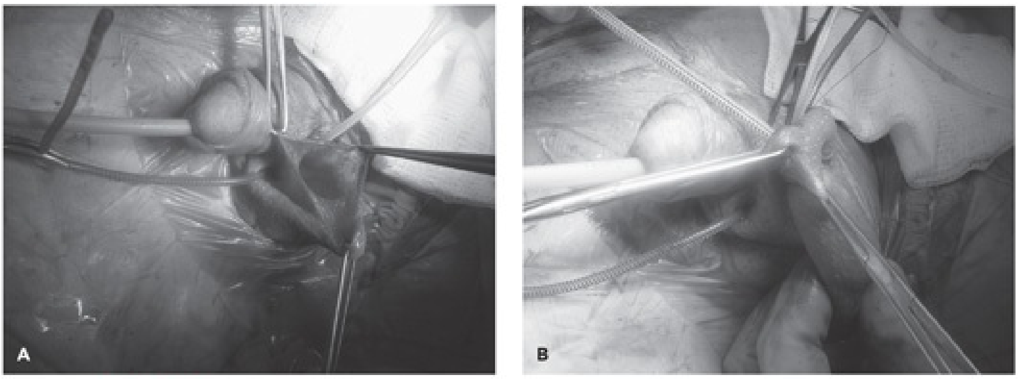

FIGURE 45.11 **A:** Creation of a subdartos pouch with the transverse scrotal incision for placement of the pump. **B:** The AUS pump is in position in the scrotum and is held by a Babcock clamp.

Bladder Neck Cuff Placement

AUS implantation with bladder neck cuff is indicated in women and poor quality of bulbar urethra after multiple prior failed attempts to achieve continence with bulbar urethral cuff placement. Bladder neck cuff is also used in conjunction with augmentation cystoplasty in patients with neurogenic bladder. Scarring at the bladder neck from prior surgery is an adverse factor to achieve optimal results with this technique. There is a risk of potential rectal injury with this approach especially in the presence of scarring.

A suprapubic incision is made to allow direct access to the prevesical space. Using blunt dissection, the prostate, bladder neck, and endopelvic fascia are exposed. A plane between the rectum and bladder is developed for the purposes of cuff placement. Incision of endopelvic fascia is surgeon-dependent and may help with mobilization especially if more space is required to complete mobilization of the bladder neck. When sizing the bladder neck, a larger cuff size (6 to 8 cm) may be used. A reservoir and pump are placed as described earlier; tubing is then trimmed and connected.

Artificial Urinary Sphincter Placement in Women

AUS placement in women is usually reserved for those with refractory stress incontinence or those with neurogenic bladder secondary to spina bifida. Topical estrogens may help improve urethral tissue quality and health preoperatively in postmenopausal women.

In women, it is generally accepted that the bladder neck is the only position to place the cuff. The bladder neck may be approached by either an abdominal or transvaginal approach. There is a higher risk of erosion in women due to the lack of a plane between the urethra and the vagina. In an abdominal approach, a low transverse-midline incision is used. A careful circumferential mobilization is performed around a 2-cm portion of the bladder neck (Fig. 45.12). Next, a sizer is used to determine the correct size cuff to place. The PRB is then placed in the paravesical space; the pump is placed in a developed subcutaneous pouch in the ipsilateral labia majora. The tubing is trimmed and connected in the usual fashion.

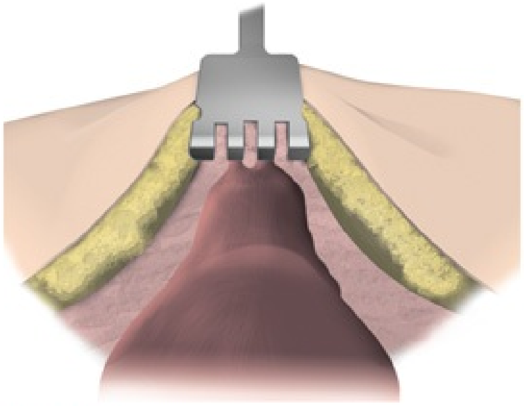

FIGURE 45.12 The abdominal approach to implantation of the AUS in women. The bladder neck region has been dissected ready for placement of the cuff.

The transvaginal approach closely resembles the perineal approach in men. An inverted U incision is used on the anterior aspect of the anterior vaginal wall at the level of the bladder neck. The bladder neck is circumferentially freed with care being taken to avoid entering the urethral lumen anteriorly. Once the urethra is freely dissected, the cuff is positioned. Next, a second incision is made transversely in the suprapubic area, and a reservoir is placed in a similar manner as described before. Tunneling to the labia majora is performed to allow placement of the pump in a subcutaneous pouch. The tubing is passed, trimmed, and connected. The vagina is packed to prevent bleeding until the following day when it is removed. The urethral catheter is left in place for 24 to 48 hours.

Synchronous Artificial Urinary Sphincter and Inflatable Penile Prosthesis Implantation

Combined implantation of both a penile implant and AUS is most commonly performed in the postprostatectomy setting. In the past, this has been performed as a staged procedure. However, with the advent of the transscrotal approach for placement of the AUS, it is possible to implant both AUS and inflatable penile prosthesis (IPP) via the same incision. Complication rates of the implantation including device erosion, infection, and/or malfunction were no different in combined versus staged procedures in one study (12).

After a high transverse scrotal incision is made, the scrotal septum is divided to free the corpora cavernosa and the corpus spongiosum of the urethra. The bulbar urethra is dissected-free and the AUS cuff is placed. Corporotomies are then performed for insertion of the cylinders of penile prosthesis. The respective reservoirs are placed via small transverse suprapubic incisions on each side. Their respective pumps are placed in the scrotum using developed subdartos pouches. After the tubing is connected and each implant tested, both should be deactivated. It has been recommended that AUS be placed before penile prosthesis. Patients requiring both AUS and IPP may be offered synchronous implantation, as this avoids a secondary procedure, which saves the patient both cost, recovery time, and potential morbidity (13). Both implants must be deactivated for a period of 4 to 6 weeks to allow time for healing.

Lee et al. (14) recently reported that combination therapy should be considered in all cases of erectile dysfunction and stress urinary incontinence, the latter from intrinsic sphincter deficiency. They evaluated both combinations of IPP/AUS versus IPP/male sling. Appropriate combination implants are recommended depending on the severity of stress urinary incontinence and the extent of intrinsic sphincter dysfunction.

Artificial Urinary Sphincter in the Pediatric Population: Simultaneous Artificial Urinary Sphincter with Bladder Augmentation

In patients with congenital neurogenic bladder and/or exstrophy-epispadias complex, the goals of treatment include preservation of renal function, prevention of recurrent urinary tract infections, and correction the underlying urinary incontinence. Although it is possible to undertake AUS implantation at the time of augmentation cystoplasty (for refractory neurogenic bladder dysfunction), this option may be considered on an individual basis as in a proportion of such patients the stress incontinence may abate or become less bothersome due to the low pressure in the augmented bladder.

Continence rates up to 80% or higher after the combined augmentation cystoplasty and AUS implant have been well documented. However, complications of AUS itself still raises concern for erosion, infection, and mechanical failure requiring explantation in up to 25% of patients in some cohorts (15). A recent review by Viers et al. (16) examined a cohort of patients undergoing cuff-only AUS versus complete AUS placement with augmentation cystoplasty (Table 45.2). The authors noted that cuff-only AUS placement was safe and efficacious in patients with neurogenic bladder, with decreased complication rates compared to a complete AUS implant.

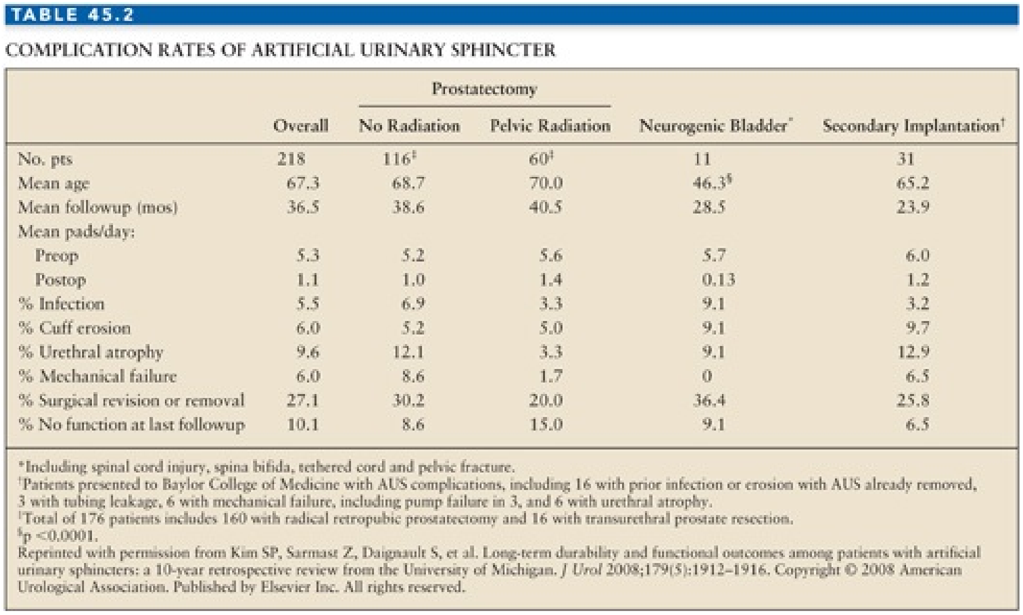

TABLE 45.2

COMPLICATION RATES OF ARTIFICIAL URINARY SPHINCTER

		Prostatectomy			
	Overall	No Radiation	Pelvic Radiation	Neurogenic Bladder[*]	Secondary Implantation[†]
No. pts	218	116[‡]	60[‡]	11	31
Mean age	67.3	68.7	70.0	46.3[§]	65.2
Mean followup (mos)	36.5	38.6	40.5	28.5	23.9
Mean pads/day:					
Preop	5.3	5.2	5.6	5.7	6.0
Postop	1.1	1.0	1.4	0.13	1.2
% Infection	5.5	6.9	3.3	9.1	3.2
% Cuff erosion	6.0	5.2	5.0	9.1	9.7
% Urethral atrophy	9.6	12.1	3.3	9.1	12.9
% Mechanical failure	6.0	8.6	1.7	0	6.5
% Surgical revision or removal	27.1	30.2	20.0	36.4	25.8
% No function at last followup	10.1	8.6	15.0	9.1	6.5

[*] Including spinal cord injury, spina bifida, tethered cord and pelvic fracture.

[†] Patients presented to Baylor College of Medicine with AUS complications, including 16 with prior infection or erosion with AUS already removed, 3 with tubing leakage, 6 with mechanical failure, including pump failure in 3, and 6 with urethral atrophy.

[‡] Total of 176 patients includes 160 with radical retropubic prostatectomy and 16 with transurethral prostate resection.

[§] $p < 0.0001$.

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Levesque et al. (17) noted in a 10-year study that it is important to educate the patient on the need for close follow-up. They noted that 11% of patients who developed renal failure and recurrent incontinence were lost to follow-up. It is also prudent to watch for post-AUS bladder dysfunction and educate the patient and parents that postprocedure self-catheterization may be necessary.

Tandem Cuff Placement for Artificial Urinary Sphincter

In the salvage setting, Guralnick et al. (9) previously reported the use of transcorporeal placement of the cuff. Recently, tandem-cuff placement has emerged as a viable option. In situations where the primary AUS has not resolved incontinence but was not shown to be infected or eroded thus not requiring explantation, tandem cuff placement is a reasonable option in lieu of revising the primary cuff and potentially incurring urethral injury. Placing a tandem cuff by the transcorporeal approach has shown promising results with lower complication rates. Magera and Elliott (18) have described this technique. This approach was noted to decrease pad use with 69% of patients reported feeling extremely improved. Other options in such patients include downsizing the cuff. Cuff downsizing is an option following cuff atrophy resulting in recurrent stress incontinence.

In the transcorporeal approach, as described earlier, the cuff is placed distal to the bulbar urethra; the tunica albuginea from the bilateral corporotomies is used to provide additional bulk around the thinner urethra. The corporotomies are closed prior to cuff placement, and the tubing is passed and delivered through a lower abdominal incision and connected into the existing system using Y connectors. A reservoir with 61- to 70-cm H_2O pressure should be used and the system deactivated for 4 to 6 weeks to allow for healing. The urethral catheter may be removed 24 hours after device implantation. Once the system is activated, nocturnal deactivation should be performed by the patient to prevent urethral atrophy (18).

COMPLICATIONS AND OUTCOMES

In the early postprocedure period, common complications include urinary retention and wound hematoma usually around the control pump. Retention is usually managed with temporary urethral catheter placement or intermittent catheterization, whereas hematomas are usually managed by supportive care. It is extremely important to be cognizant of the risk of urethral cuff erosion from the trauma and/or pressure necrosis of the indwelling catheter. Inappropriate catheter placement is a well-known cause for urethral cuff erosion. If at all an indwelling catheter becomes necessary, the AUS should be deactivated, and after intraurethral copious lubricant instillation, a small catheter is inserted by an experienced urologist for the shortest possible duration. In a 10-year outcomes study encompassing 124 patients, Kim et al. (19) reported 37% overall complication rate with 12.5% requiring explantation.

AUS infection has been reported in less than 2% of patients, with the most common organism being *Staphylococcus aureus*, followed by *Staphylococcus epidermidis* (5). In recent years, the antibiotic (rifampin and minocycline)-coated AUS has been introduced and is designed to release antibiotics over a period of 1 to 2 weeks in an effort to reduce infection rates. Currently, it is controversial on whether this significantly reduces infection rates (20).

However, in the 10-year outcomes study, the rate of infection in a cohort of 124 patients was noted to be 5.6%, whereas erosion was reported in 8% of patients (19). Lai et al. (21) also reported similar infection rates in their cohort of 270 patients with infection and erosion in 5.5% and 6%, respectively.

Following explantation, the standard waiting period until reimplantation of a new device is 3 to 6 months. Lai and Boone (22) recently reported that AUS reimplantation subsequent to removal of the AUS for infection or erosion, carried a fourfold increase in erosion of the reimplant. Linder et al. (23) reported similar results including 19% explantation rate of the secondary implant versus 6.4% with the primary AUS.

Mechanical failure is the most common complication noted with AUS placement usually attributed to wear and tear. Since the 11-year study in 2000 by Venn et al. (19,21,24) reporting 32% mechanical failure. Elliott et al. (25) published this decrease in the mechanical failure after the introduction of “narrow back design” of the cuff as a decrease from 21% to 7.6%. The improvement may be related to design modifications of the AUS including the narrow-backed cuff and kink-resistant tubing.

Patients with recurrent incontinence should be subjected to a full workup evaluating the bladder, urethra, and functioning of the implant to diagnose cuff-related urethral atrophy, mechanical malfunctioning, bladder neck contracture, urethral stricture, and/or detrusor overactivity. The workup may include physical examination, cystoscopy, and/or videourodynamic study. It is of paramount importance to ensure that the patient is properly using the implant and that appropriate patient instructions have been provided and are well understood. If urethral atrophy is noted, cuff downsizing may be performed. Tandem cuff placement may also be useful in this scenario. Detrusor overactivity and leak point pressure measurement are noted by urodynamic study and the appropriate treatment undertaken. Patients with neurogenic bladder dysfunction may need bladder augmentation.

A recent systematic review evaluated overall outcomes for patients undergoing AUS implant. Mean infection/erosion rate across all studies was noted to be 8.5%, whereas mechanical failure rate and urethral atrophy rate were found to be 6.2% and 7.9%, respectively. Seventy-nine percent of patients reported ≤1 pad use per day, whereas 43.5% of patients were noted to be completely dry (Table 45.3) (26). Mechanical failure rates were usually related to pump failure. Revision surgery varied from 0% to 41.3% (27).

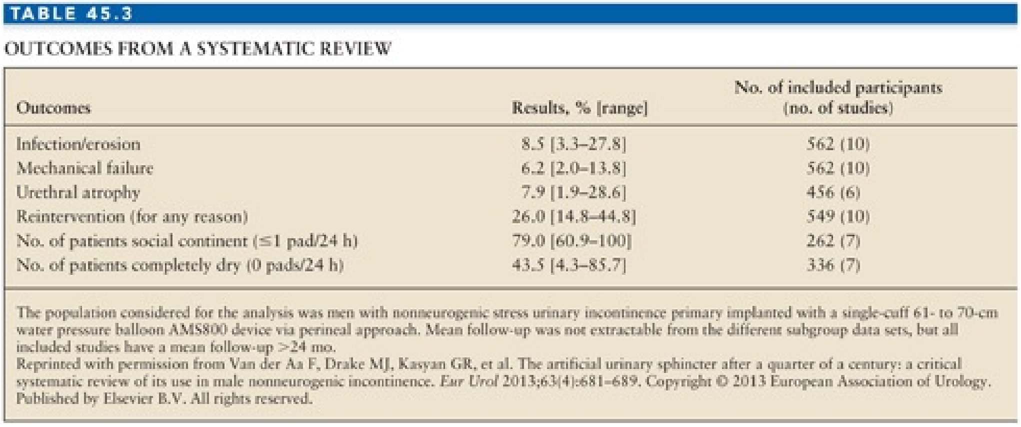

TABLE 45.3

OUTCOMES FROM A SYSTEMATIC REVIEW

Outcomes	Results, % [range]	No. of included participants (no. of studies)
Infection/erosion	8.5 [3.3–27.8]	562 (10)
Mechanical failure	6.2 [2.0–13.8]	562 (10)
Urethral atrophy	7.9 [1.9–28.6]	456 (6)
Reintervention (for any reason)	26.0 [14.8–44.8]	549 (10)
No. of patients social continent (≤1 pad/24 h)	79.0 [60.9–100]	262 (7)
No. of patients completely dry (0 pads/24 h)	43.5 [4.3–85.7]	336 (7)

The population considered for the analysis was men with nonneurogenic stress urinary incontinence primary implanted with a single-cuff 61- to 70-cm water pressure balloon AMS800 device via perineal approach. Mean follow-up was not extractable from the different subgroup data sets, but all included studies have a mean follow-up >24 mo.

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Outcomes of Artificial Urinary Sphincter Placement after Prior Failed Male Sling

In a recent cohort study of 29 men with failed male sling placement in the setting of postprostatectomy incontinence that subsequently underwent AUS placement, 96% of men were found to be using ≤1 pad at 3 months follow-up (28). Men with AUS implant following prior failed male sling had comparable outcomes to men who received primary AUS implantation. Long-term continence rates of over 90% were reported following AUS implant for postprostatectomy urinary incontinence (24).

Artificial Urinary Sphincter Implantation Following Prior Radiotherapy for Prostate Cancer

Prior radiation therapy was in the past considered to result in higher complication rates following AUS placement. Kim et al. (19) reported a higher rate of bladder neck contracture in radiated patients relative risk (RR 2.1). However, recent studies have shown no significant difference in the rates of erosion, infection, and urethral atrophy between groups of men that were irradiated versus nonradiated. However, larger studies need to be performed to determine if there is a significant difference in the AUS outcomes in patients that received radiation (29).

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CHAPTER 46 ■ THE MALE SLING FOR POSTPROSTATECTOMY INCONTINENCE: CURRENT CONCEPTS AND CONTROVERSIES

YING H. JURA AND CRAIG V. COMITER

PREVALENCE OF POSTPROSTATECTOMY INCONTINENCE

The most common cause of stress urinary incontinence (SUI) in men is iatrogenic injury during prostate surgery. The rate of incontinence following surgery for benign prostatic hyperplasia is approximately 2% (1). In contrast, the risk of urinary incontinence is significantly higher following surgery for prostate cancer. In a questionnaire-based study by Stanford et al. (2), postprostatectomy patients were evaluated using a self-administered questionnaire. Only 32% claimed total urinary control, 40% had occasional leakage, 7% had frequent leakage, and 2% suffered from no control at 2 years postoperatively (2). Although reports of postprostatectomy incontinence (PPI) vary, contemporary cohort studies demonstrate that 1% to 5% of patients will ultimately undergo surgery for the management of their incontinence after radical prostatectomy (2–5).

RISK FACTORS FOR POSTPROSTATECTOMY INCONTINENCE

The surgical technique for radical prostatectomy (RP) has become relatively standardized, with improved instrumentation and visualization, especially following the adoption of robotic assistance. There are, however, recognized risk factors for PPI. These risk factors include age, preoperative continence status, preoperative voiding dysfunction, tumor stage, obesity, prior radiation or transurethral resection of the prostate, vascular disease, preoperative membranous urethral length, and postoperative radiation or cryotherapy (6–14). Although many of these risks may not be modifiable, they may alter cancer treatment choice.

The most predictive risk factors for PPI are preoperative urinary incontinence and voiding dysfunction. Stress incontinence in men who have not had prostate cancer surgery occurs at a baseline prevalence of 1.3% to 4.8% (15). Whereas urgency and overflow incontinence associated with bladder outlet obstruction may indeed resolve following surgery for this condition, preoperative SUI typically will not improve postoperatively (6). Rather, baseline intrinsic sphincteric deficiency (ISD), demonstrated either by the preexisting clinical sign of SUI or the urodynamic finding of low maximal urethral closure pressure, strongly predicts postoperative SUI (13,14). Preoperative bladder dysfunction also increases the risk of PPI, especially in those with neurogenic detrusor overactivity secondary to Parkinson disease, dementia, or spinal cord injury (7).

DIAGNOSIS

Evaluation of the patient with PPI should begin with a detailed history of lower urinary tract symptoms. As the pathophysiology of PPI is variable and history alone is not sufficient to distinguish between bladder causes (poor compliance, detrusor overactivity, detrusor underactivity) and outlet causes (sphincteric insufficiency or bladder outlet obstruction) of incontinence, a micturition diary is useful for quantifying frequency, incontinence episodes, and functional bladder capacity. It is important to demonstrate leakage on physical examination to confirm the diagnosis of SUI. Leakage should occur during cough or Valsalva and cease at the end of the straining maneuver. Although this confirms the presence of ISD, it is not a definitive test of bladder storage or voiding function.

Urodynamic evaluation is strongly recommended prior to consideration of invasive therapy. Filling cystometry can assess bladder storage, and antegrade or retrograde leak point pressure may provide information on outlet function. The majority of men with PPI suffer from ISD, but only 25% to 50% will have ISD alone on urodynamics. Approximately 15% of patients with PPI demonstrate only bladder dysfunction without ISD, and 40% of patients with ISD will demonstrate concomitant bladder dysfunction (16). Bladder dysfunction may result from preexisting outlet obstruction, or age-related detrusor overactivity, or may occur de novo after prostatectomy as a result of bladder denervation. Impaired detrusor contractility, which occurs in 29% to 61% of patients (de novo in approximately 47%), and poor compliance, which occurs in 8% to 39% of patients (de novo in approximately 50%), have traditionally been thought to resolve within 8 months (17,18).

Although pad use, bother from leakage, and patient preference typically dictate the implementation of surgical treatment, it is important to quantify the degree of sphincteric incompetence, as this factor may affect the type of treatment recommended for the management of the stress incontinence. For example, patients with higher abdominal leak point pressure (ALPP), and therefore more preserved sphincteric function, tend to respond better to periurethral bulking agents than do patients with a lower ALPP (19).

INDICATIONS FOR SURGERY

Surgical intervention is indicated for treating bothersome SUI due to ISD that fails to adequately improve following 12 months of conservative management. Most patients will experience improvement in leakage for up to 1 year following surgery, regardless of active (pelvic floor physiotherapy) or passive (observation) management (20).

Severity, effect on quality of life, and the ability of the patient to conservatively manage incontinence must be balanced against the risks of surgery. In addition, reasonable physician and patient expectations based on clinical efficacy, acceptable morbidity (severity, duration, and need for additional therapy), and the avoidance of serious complications are essential. Implantation of a surgical device should be undertaken with caution in patients with uncontrolled detrusor overactivity or decreased bladder compliance. In addition, those conditions that may require future transurethral management (i.e., urethral stricture or bladder neck contracture) are relative contraindications to outlet surgery because repeated instrumentation may put the patient at risk for device infection or erosion.

Due to lack of U.S. Food and Drug Administration (FDA)–approved pharmacotherapy for ISD, and generally poor efficacy of periurethral bulking agents (21), surgery remains the primary treatment modality for the management of PPI. Surgical approaches include implantation of an artificial urinary sphincter (AUS), or placement of a male sling (MS). This chapter will focus on the surgical technique of the most popular MS surgeries.

ARTIFICIAL URINARY SPHINCTER

In contrast to the low-pressure coaptation of periurethral bulking, the AUS relies on circumferential occlusion of the urethra using a pressurized inflatable cuff. For more than three decades, the AUS has represented the most efficacious treatment for male SUI treatment, with satisfaction rates typically greater than 80%, regardless of the degree of incontinence. The majority of men with PPI are appropriate candidates for AUS placement, with exception of those who may lack the mental faculties and manual dexterity to cycle the scrotal pump and properly work the system.

The AUS has been reported to have a predictably high success rate regardless of the degree of incontinence, even in the setting of detrusor dysfunction such as overactivity, or diminished vesical compliance (22). In men who had presumably normal storage function prior to RP, the urodynamic findings of detrusor overactivity or diminished compliance are most likely due to a supraphysiologic infusion rate of filling medium into a bladder that has experienced a prolonged underfilled state secondary to continual urinary leakage. Preoperative detrusor overactivity does not adversely affect resolution of SUI following AUS implantation, but persistent overactive bladder symptoms are common, and patients must be counseled accordingly (22). Detrusor hypocontractility does not adversely affect surgical success because the AUS is cycled to an "open" phase during voiding, with relief of urethral occlusion.

The AUS, however, has a nontrivial complication rate. It has revision rates of 8% to 45% and explantation rates of 7% to 17% due to mechanical failure, urethral atrophy, infection, and erosion (23,24). Despite high success rates, the high cost and high revision rates have inspired the search for less expensive, less invasive, and less complicated devices. In addition, patients are often apprehensive about a mechanical device that requires manipulation prior to voiding. The modern MS has been actively studied and refined over the past decade in an effort to minimize invasiveness and overcome these hurdles.

MALE SLING

Various slings are currently available for the treatment of PPI. With the recent withdrawal of the bone-anchored sling from the market, the most commonly used devices are the retrourethral transobturator sling (RTS), the quadratic sling, and the adjustable pubourethral sling.

RATIONALE FOR THE MALE SLING

The impetus for the design of the modern MS was to decrease the risk of device infection, urethral erosion, and urethral atrophy that can be associated with a circumferential urethral compression and to allow for spontaneous voiding without the need for device manipulation. The MS is a noncircumferential suburethral device that is placed with the aim of applying sufficient urethral occlusive pressure to prevent leakage yet permit normal spontaneous voiding without the need for device manipulation. Recent experience with the MS has taught several lessons regarding the management of PPI with sling surgery: (a) Adequate but not excessive tension is necessary for urethral compression and continence; (b) well-designed synthetic materials have an acceptably low rate of infection and erosion; (c) adequate detrusor contractility is necessary to overcome the fixed resistance of certain slings; (d) various methods of sling fixation can achieve successful urethral compression; (e) there is no "best" sling for all patients—rather different patient types may be best treated with different slings; and (f) patients with more severe or total urinary incontinence appear to have a lower success rate with the MS than do patients with more mild to moderate degrees of incontinence (25,26).

RETROURETHRAL TRANSOBTURATOR SLING

Surgical Technique

The most commonly performed sling procedure for the treatment of PPI is currently the RTS. As the mechanism of action of this sling is thought to rely more on repositioning the prolapsed sphincteric urethra than on direct compression of the bulbar urethra, it is recommended that preoperative evaluation include the "repositioning" test to verify the presence of adequate residual sphincter function. Rehder's group demonstrated that the ALPP increases on gently pushing the perianal midperineum in a cephalad direction (avoiding direct compression of the urethral bulb). Men with sufficient residual sphincter function (i.e., mild ISD) demonstrate passive sphincter closure with cystoscopically visible contraction of the striated sphincter on perineal elevation (27). This provocative maneuver, by increasing the “zone of coaptation,” augments pressure transmission within the functional sphincteric unit, and when demonstrated preoperatively, is predictive of a successful surgical outcome (28,29). In those men with adequate residual sphincter function, a retroluminal transobturator sling is appropriate.

The surgery is performed under general anesthesia with the patient in a lithotomy position. A negative urine culture is required prior to surgery. Intravenous cephazolin (or vancomycin plus gentamicin, if allergic) is given within 1 hour of surgery.

After the patient is prepared and draped in a sterile fashion, a 14Fr Foley catheter is passed per urethra to help identify the perineal portion of the urethra. A 3- to 4-cm midline incision centered over the bulbar urethra is made. The bulbospongiosus muscle is typically divided and dissected off the bulbospongiosum. The central tendon can be found after the bulbar urethral is exposed and a retractor is placed to isolate the urethra. By gently pulling the perineal urethra cephalad, the central perineal tendon is evident as it spans from the inferior aspect of the bulbar urethra to the perineum. With retraction of the inferior aspect of the perineal incision caudal, and countertraction of the perineal urethra cephalad, the central tending should be readily visualized. After the central tendon is identified, the fibrous portion is divided to allow approximately 2 to 4 cm of mobility of the urethral bulb (Fig. 46.1).

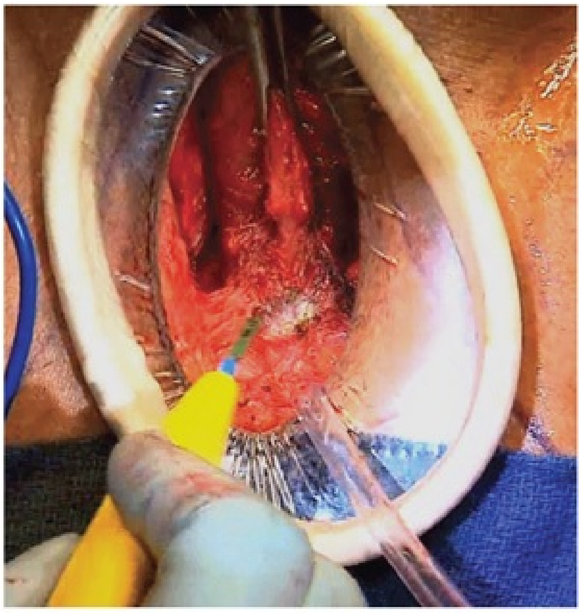

FIGURE 46.1 Identification of the central perineal tendon, aided by upward traction of the perineal portion of the urethra. Detachment of this tendon permits proximal urethral relocation.

Small stab incisions are made in each groin/thigh crease, approximately 1 cm inferior and lateral to the insertion of the adductor longus tendon at the medial border of the obturator foramen. Helical needle passers are then passed through the stab incisions, through the obturator membrane, around the inferior pubic ramus, and out at the apex of the triangle formed by the bulbar urethra medially and the ischiopubic ramus laterally. The mesh sling is then connected to the needle passers. The needle passers are rotated back along the insertion pathway to pull the sling back through the obturator foramen and out the stab incisions. The sling should be centered over the urethra. Four interrupted 3-0 polyglycolic acid sutures are then placed to secure the midportion of the sling to the bulbospongiosum just distal to the central tendon. Fixation of the sling to the periurethral tissue prevents "slippage" of the sling too far proximally and actually *off* the posterior aspect of the urethra, which can reduce sling efficacy.

To tension the sling, both arms of the sling are pulled laterally. This should be done after removal of the Foley catheter. The bulbar urethra should be repositioned 2 to 3 cm proximally (Fig. 46.2). The arms of the sling may be tunneled back into the perineal incision and then trimmed. The catheter is then replaced into the bladder, and the wound is irrigated with antibiotic solution. The bulbospongiosus muscle should be reapproximated and then the wound is closed in multiple layers with running suture, using 2-0 polyglycolic acid suture for the deep layer, 3-0 polyglycolic acid suture for the dartos layer, and 4-0 polyglycolic acid suture for the skin. A trial of voiding is performed when the patient is able to stand comfortably to void, usually within 6 to 36 hours postoperatively.

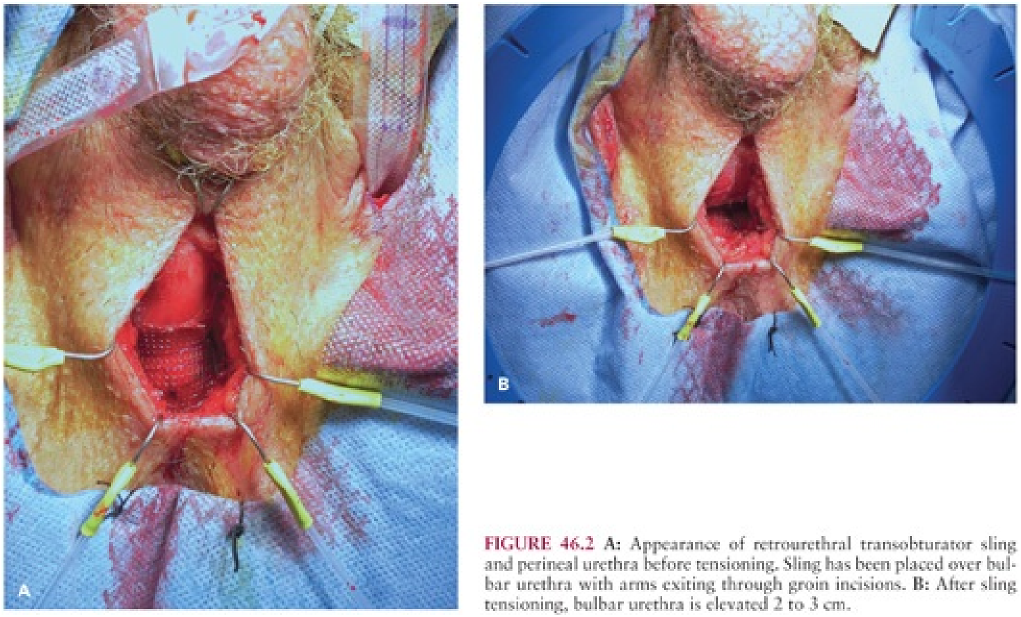

FIGURE 46.2 A: Appearance of retrourethral transobturator sling and perineal urethra before tensioning. Sling has been placed over bulbar urethra with arms exiting through groin incisions. B: After sling tensioning, bulbar urethra is elevated 2 to 3 cm.

Mechanism of Action

The retroluminal sling was introduced in 2005. It was designed to be placed through a minimally invasive transobturator (TO) placement. Its mechanism of action relies on proximal urethral relocation rather than any significant compression of the bulbar urethra. The sling is placed *retrourethrally*, under the proximal urethral bulb. Upon tensioning, a 2- to 3-cm proximal relocation of the bulbar urethra is achieved.

It is hypothesized that laxity of posterior support predisposes to misalignment of the proximal urethra and thereby contributes to ineffective coaptation of the urethral sphincter complex (28). The retroluminal sling can remedy the abnormal anatomy and proximal urethral prolapse that may occur following prostate extirpation. Once the sling is appropriately tensioned, the urethral bulb is proximally relocated 2 to 3 cm into the higher pressure pelvic outlet and can function as a "backstop" during straining (30). Risk factors for failure of the TO sling include those conditions associated with poor residual sphincter function and/or a lack of urethral mobility—such as poor coaptive response to perineal elevation, a high preoperative pad weight, and a history of prior external beam radiation (29,31).

Outcomes

Surgical success can vary with the definition of continence, the method of evaluation, the length of follow-up, and the experience of the surgeon. In addition, the method of sling fixation may also contribute to the outcome of the procedure. Most series report the results of the AdVance sling (American Medical Systems, Minnetonka, Minnesota) or the TOMS (CL Medical, Lyon, France). Success is most commonly defined as cure (no pads or one security pad) or improvement (two or less pads or >50% reduction in pad use).

The cure/improved rates from prospective series have ranged from 54% to 80% at 1 year, with success remaining 75% to 78% for studies with follow-ups of up to 3 years (32). A recent prospective multicenter trial by Rehder et al. (33) with 156 patients undergoing the AdVance sling for PPI found a cure rate of 53.8% at 1 year and a cure rate of 53.0% at 3 years. Improvement rate was an additional 23.1% and 23.8% at 1 and 3 years. In multivariate analysis, pretreatment pad usage was the only independent predictor of success. Patients with mild/moderate incontinence (five or less pads per day) had a cure rate of 58.6% and an improvement rate of 23.2% compared to 42.3% cure and 25% improved for those with severe incontinence (less than five pads per day) (33). In those patients with limited residual sphincter function and restricted urethral mobility, a sling that provides a greater degree of urethral compression may be more efficacious.

The urodynamic effects of the RTS have been reported (34,35). In another prospective study by Rehder et al. (36), 115 men underwent urodynamic evaluation before and 12 months after sling surgery. There were no significant differences in detrusor voiding pressure, postvoid residual urine volume, and maximal urine flow rates. The only urodynamic variable with a significant change was the Valsalva leak point pressure at 19.3 cm H_2O before sling placement versus 42.1 cm H_2O after sling placement (36). In a smaller study with 13 patients, Davies et al. (35) reported similar findings. One patient (8%) in this series developed de novo detrusor overactivity.

Reported rates of transient urinary retention have ranged from 3% to 23%. Perineal pain ranges widely from 0% to >50%, likely due to differences in the definition of postoperative pain. Serious complications requiring revision or removal of the RTS are rare with only a few reports in the literature (32,37). Rehder et al. (33) in their 3-year multicenter prospective trial reported the following complication rates: 50% mild perineal pain, 9% transient urinary retention (resolving within 6 months), 0.6% superficial wound infection, 0.6% sling explantation due to symphysitis (33).

QUADRATIC SLING

Efforts to improve the efficacy of MS by combining the ventral elevation of the RTS with a more distal urethral compression against the perineal membrane and pubis (such as with the previously popular bone-anchored sling) led to the design of the Virtue (Coloplast, Humlebaek, Denmark) quadratic sling. This four-armed, large-pore, knitted monofilament polypropylene mesh provides *both* proximal urethral relocation via a TO component and bulbar and perineal urethral compression via a superior prepubic (PP) component (38) (Fig. 46.3).

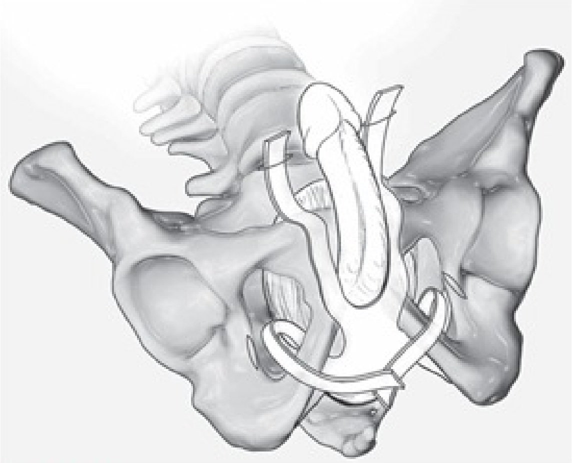

FIGURE 46.3 The quadratic sling with two transobturator arms and two PP arms.

Surgical Technique

Patients are anesthetized, given intravenous preoperative antibiotics, prepared, and draped sterilely. After inserting a 14Fr urethral catheter, a 5-cm midline perineal incision is made, and the bulbous urethra and pubic rami are exposed. The bulbospongiosus muscle is left intact to minimize the risk of urethral injury during dissection. The urethra is partially detached from the perineal body to permit the urethral bulb to move proximally similar to the RTS.

Transobturator Passage

On each side, the inferior sling extension (TO) is attached to the curved introducer and passed from the medial aspect of the descending ramus through the obturator foramen and out through a skin incision in the ipsilateral groin crease, just inferior to the adductor longus tendon. The sling is then removed from the introducer and pulled through the tissue from medial to lateral (inside to outside).

Prepubic Passage

Through two stab incisions 3 cm from the midline and 2 cm above the pubic symphysis, the curved introducer is passed from superior to inferior, staying anterior to the pubic symphysis, and out the perineal incision, lateral to the urethra on each side. The superior sling extension is attached to the introducer and pulled up through the stab incision on either side.

Sling Tensioning

The TO extensions are pulled laterally until the bulbar urethra is relocated 2 to 3 cm proximally, similar to the RTS. The TO suture tips and plastic sleeves are removed such that only mesh remains in contact with tissue. Using a long hemostat, the TO arms are then tunneled medially through the subcutaneous tissue of the perineum back to the midline incision. This permits maintenance of tension while the PP arms are manipulated upward to provide visual compression of the sling against the bulbar and perineal urethra. Retrograde leak point pressure (RLPP) is measured via perfusion sphincterometry with a 14Fr catheter in the penile urethra (38) and PP sling tension is adjusted sufficiently to increase the RLPP to 60 to 70 cm H_2O. The PP suture tips and plastic sleeves are removed, and the PP mesh is cut flush to the suprapubic skin.

Sling Fixation

After the TO extensions are tunneled subcutaneously back to the midline perineal incision, they are sutured together in the midline with a 0-polypropylene suture. Following PP passage, fixation of the superior sling arms is accomplished by suturing the superior extensions, just above their attachment to the body of the sling, to the soft tissue overlying the pubic bone (Fig. 46.4).

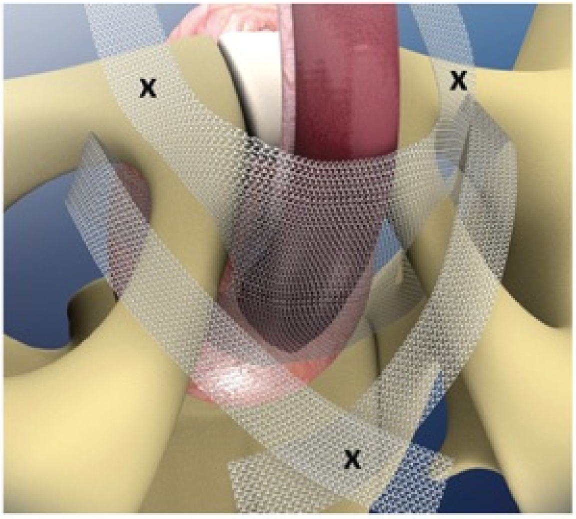

FIGURE 46.4 The quadratic sling is fixed by suturing the superior arms, just above their attachment to the body of the sling (*X*), to the soft tissue over the pubis and by suturing the transobturator extensions in the midline (*X*).

Finally, the perineal incision and stab wounds are irrigated and closed. The urethral catheter is maintained overnight and removed the following morning at home. Patients are instructed to refrain from strenuous activity for 8 weeks.

Mechanism of Action

This hybrid device is based on the combination of proximal urethral relocation (similar to RTS) and perineal urethral compression (similar to bone-anchored slings). Comiter et al. (38) investigated the urethral resistance exerted by the sling in 22 men using RLPP, measured by perfusion sphincterometry, at various steps during the surgical procedure. They found that RLPP increased from a mean baseline value of 33.4 ± 8.8 cm H_2O to 43.3 ± 6.8 cm H_2O after TO tensioning and to 55.8 ± 8.7 after PP tensioning. The final RLPP after TO and PP fixation increased to 68.8 ± 6.0 cm H_2O. Each mean RLPP value was significantly higher than the preceding value (38).

Outcomes

Results of the quadratic sling demonstrate improvements in urinary continence that are similar to those reported for the bone-anchored sling and the RTS. In the initial cohort of 100 men that underwent VIRTUE sling placement in a multinational clinical trial with an unfixed device, despite early success, sling efficacy deteriorated over time due to a lack of surgical fixation of the sling (39). However, with a straightforward sling fixation of the TO arms (tunneled back to the midline) and the PP arms (to the soft tissue over the pubic symphysis), excellent efficacy has been maintained over a 12-month period. In a multinational FDA-monitored clinical trial, success (>50% reduction in pad weight) was achieved by 79% at 1 year, with an overall 88% decrease in pad weight from a median of 147 g preoperatively to 18 g postoperatively. There were no cases of prolonged urinary retention, infection, or sling erosion, and 12.9% experienced temporary perineal pain, which resolved in all but one patient at 1 year postoperatively. In addition, the efficacy of the quadratic sling did not significantly differ among patients with mild (<100 g per day), moderate (100 to 400 g per day), or severe (>400 g per day) SUI (40). In addition, there was no significant change in postvoid residual urine following sling placement in this cohort.

ADJUSTABLE MALE SLINGS

Adjustable slings allow for sling tensioning intraoperatively, and retensioning postoperatively, if deemed necessary. Although not available in the United States, they are available in Canada and Europe. The Argus (Argus, Promedon SA, Cordoba, Argentina) consists of a silicone foam pad placed under the bulbar urethra that is attached to retropubically passed silicone columns. These columns are secured over the rectus fascia with silicone washers. A small suprapubic incision is needed to access the washers for adjusting tension postoperatively. The Remeex (Neomedic, Barcelona, Spain) bulbourethral sling, another adjustable device, consists of a synthetic mesh that is placed under the bulbar urethra and suspended by retropubically passed sutures. The sutures are secured to a "varitensor" device anterior to the rectus fascia. A "manipulator" is used to tighten or loosen the sling to the desired tension. The varitensor may be reaccessed with local anesthesia to adjust tension.

Both slings have shown to have good long-term success rates but also high complication rates. The success rates of the Argus have ranged from 72% to 79% at a mean follow-up of 26 to 45 months (41–43). The Remeex was evaluated in a multicenter trial with 51 patients followed for 32 months. The success rate was 85% (44). Complications with the Argus include erosion (13%) and sling infection requiring explant (11%) (41–43). Complications with the Remeex include bladder perforation (10%), varitensor infection requiring explant (4%), and erosion (2%) (44). It does not appear that the adjustable slings provide a markedly improved outcome compared to the RTS and the quadratic sling but may have substantially greater morbidity.

WHICH PROCEDURE IS BEST FOR WHICH PATIENT

Adequate tissue compliance is necessary for successful urethral compression and/or proximal repositioning with a sling. Not surprisingly, radiation, previous AUS explantation, and prior MS—all of which may result in poorly compliant and relatively noncompressible fibrotic urethra—are associated with diminished efficacy for the noncircumferential MSs. Because the AUS can provide the circumferential urethral compression necessary for adequate coaptation in such cases, it is the treatment of choice for patients who have had prior radiation or previous AUS or MS.

Full-course external beam radiotherapy reduces the efficacy of sling surgery. In a prospective series with 24 radiated patients followed for a median of 18 months after placement of an RTS, Bauer et al. (45) found only a 25% cure rate and a 25% improvement rate. In another series with both nonradiated (86%) and radiated patients (14%), Bauer et al. (45) found a history of radiotherapy to be a risk factor for sling failure. This has also been found to be true in other series with RTS (36,46,47). Radiation has also been shown to adversely affect the success of the original pubourethral sling (48) and the BAS (25).

In men who have failed prior MS surgery, placement of the AUS remains a straightforward procedure. With prior RTS, the surgeon may elect to place the AUS cuff transscrotally, and the previous sling neither renders the operation more difficult nor decreases AUS efficacy (3,25). With the quadratic sling, the polypropylene sling may be readily identified and dissected off the underlying muscle. The bulbospongiosus may then be split and dissected off the underlying spongy urethra, and the AUS may be placed in routine fashion (Fig. 46.5).

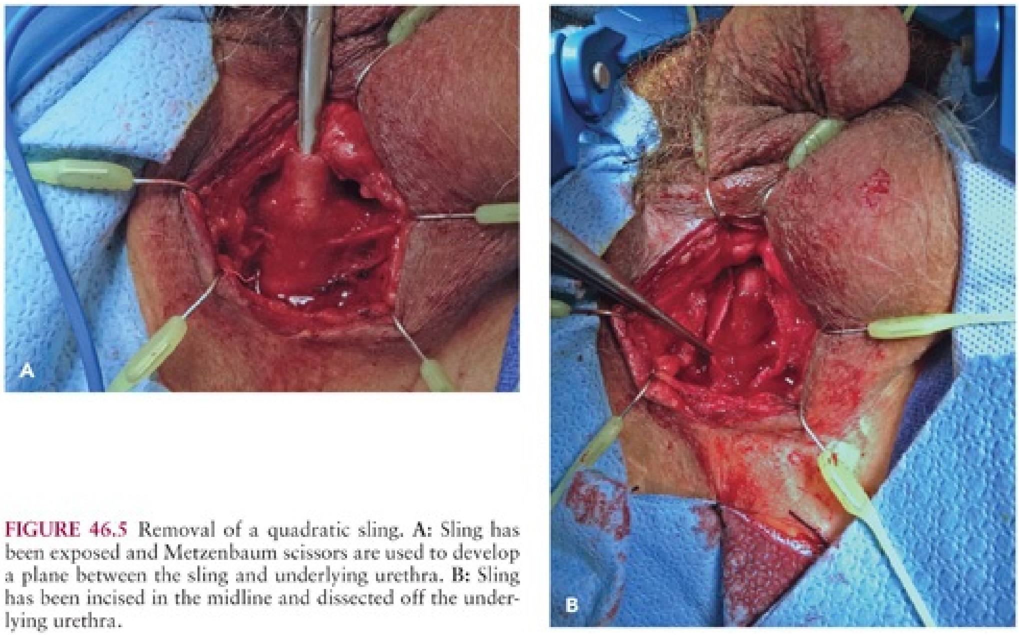

FIGURE 46.5 Removal of a quadratic sling. A: Sling has been exposed and Metzenbaum scissors are used to develop a plane between the sling and underlying urethra. B: Sling has been incised in the midline and dissected off the underlying urethra.

Maintaining sling tension and position along the urethra is critical for sustained efficacy. The last decade has taught us that sling tension (and therefore efficacy) is more adequately maintained with a permanent synthetic material compared to a resorbable allograft or xenograft (49). Additionally, the adequacy of sling fixation strongly affects continence rates regardless of the particular type of sling. Early sling slippage will typically result in recurrent SUI. This problem, however, has been overcome with improvements in sling fixation. With respect to the RTS, inadequate fixation of the sling to the urethra and insufficient sling tunneling are associated with a higher rate of recurrent incontinence (31). Similarly, inadequate fixation of the quadratic sling has been associated with a higher risk of early sling failure (40).

Finally, the degree of incontinence has been shown to impact efficacy. Multiple reports demonstrated that patients with more severe incontinence preoperatively are at higher risk for postoperative incontinence following sling surgery (33,47,50). In a prospectively evaluated cohort of 62 patients with PPI, Fischer et al. (50) demonstrated that men with <423 g leakage per day were 6 times more likely to achieve satisfactory continence compared to those with a higher preoperative pad weight tests. Thus, AUS is the treatment of choice for most men with high-volume SUI, as AUS success rates are generally independent of the degree of leakage.

In men with mild to moderate SUI (<400 g per day) and normal bladder contractility, the MS may be preferable as an initial procedure because an AUS can still be offered after sling failure, whereas previous placement of an AUS is a relative contraindication to sling surgery. In addition, the MS has emerged as the preferred surgical option among patients with PPI. When offered a choice between MS and AUS, the majority of patients will opt for the MS in order to avoid a mechanical device (51). For those with milder leakage, the TO approach has reported efficacy of 60% to 85% with very few complications. For men with more moderate incontinence, the quadratic sling may have better efficacy based on a broader area of urethral compression in addition to proximal urethral elevation.

SUMMARY

Male SUI is usually iatrogenic and can be a bothersome complication of prostate cancer surgery, causing approximately 10% of patients to seek further treatment. After 12 months of active conservative management, surgical intervention is often indicated. Transurethral injection of bulking agents, although minimally invasive, has no proven short- or long-term success. The AUS and suburethral sling are both safe and efficacious treatments for PPI secondary to ISD.

For high volume incontinence, including total urinary incontinence due to severe sphincteric insufficiency, the AUS appears to have higher efficacy than does the MS. For mild to moderate SUI, the success rates for MS and AUS appear more or less equivalent. In these patients, the MS may be the preferred option in many patients due to lower complication and revision rates and ability to void without device manipulation. In fact, if given the choice between MS and AUS surgery, the majority of patients will choose sling placement in order to avoid a mechanical device (51). Although spontaneous voiding is a relative advantage of the MS, the patient requires adequate detrusor contractility to overcome the resistance of a compressive sling. Thus, both the AUS and the MS represent efficacious and acceptably safe methods for the treatment of PPI, but each has its specific role in managing patients with different degrees of leakage and bladder voiding function.

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CHAPTER 47 SACRAL NEUROMODULATION

CHRISTOPHER F. TENGGARDJAJA AND SANDIP VASAVADA

Overactive bladder (OAB) symptoms are projected to affect 34 million people in the United States, with a projected national cost of $76 billion in 2015 (1,2). OAB is defined as urinary urgency with or without incontinence commonly associated with frequency and nocturia (3). Patients treated for OAB symptoms undergo behavioral modification in addition to pharmacotherapy. By the time these patients reach the urologist, they usually have refractory symptoms. Sacral neuromodulation (SNM) has proven to be a durable and successful treatment for refractory OAB patients.

Our knowledge of electrical stimulation for neuromodulation is dependent on prior neurophysiologic studies. In the 1800s, work in canine models localized preservation of sensation versus motor function to respective intact dorsal or ventral spinal nerve roots. Selective transection of pelvic and hypogastric nerves helped to further determine their effects on bladder function and micturition. These physiologic observations laid the foundation for our present day techniques. By 1960, several studies began exploring the feasibility of selective nerve root activation with electrical activity. Schmidt et al. (4) demonstrated the ability to induce voiding in canine models with stimulation of sacral nerve roots. Brindley et al. (5) demonstrated improved voiding in spinal cord injury patients with implantation of sacral anterior root stimulators. The placement of neurostimulators has evolved from morbid open cut-down procedures involving laminectomies to minimally invasive percutaneous image-guided techniques. First approved in Europe in 1994, SNM was approved by the U.S. Food and Drug Administration (FDA) for urgency urinary incontinence

(UUI) in 1997 followed by urgency-frequency syndrome and nonobstructive urinary retention (UR) in 1999. Most recently, SNM was approved for the treatment of fecal incontinence (FI) in 2011 (InterStim, Medtronic, Inc). This chapter focuses on the indications, techniques, and outcomes for implantation.

MECHANISMS OF ACTION OF SACRAL NEUROMODULATION

Urinary storage and emptying are facilitated by complex interactions between the central and peripheral nervous systems. Urinary storage is facilitated by lumbar sympathetics and pudendal efferent activation. Micturition is activated by sacral parasympathetics and pudendal relaxation of the external urinary sphincter. SNM is thought to affect both afferent and efferent activity to allow for detrusor relaxation and also cause selective inhibition at the spinal and supraspinal levels (6). Given that SNM is effective in both OAB and nonobstructive UR, it is thought that different pathways are modulated in each patient group with a return to “normal neurophysiology.” For patients with OAB who possibly have an unmasking of a primitive reflex or abnormal sensory afferent discharge, SNM may act on pudendal nerve afferents regulating abnormal activation and inhibiting interneuronal transmission leading to a modulation of sensory outflow to the pontine micturition center. This subsequently prevents involuntary detrusor contractions by modulating the abnormal activation of the micturition reflex. Patients with nonobstructive UR are hypothesized to have an erroneous disinhibition of the spinal guarding and bladder afferent loop reflexes. SNM restores a normal voiding pattern by inhibiting the constant activation of these guarding reflexes (7).

DIAGNOSIS

An initial visit includes a comprehensive history and physical examination. Important aspects of the history include onset and duration of symptoms, exacerbating factors, prior failed therapies, and an assessment of quality of life. Questionnaires such as Urogenital Distress Inventory Short Form (UDI-6) and Incontinence Impact Questionnaire Short Form (IIQ-7) can aid in establishing baseline symptom scores of severity and bother. Age of the patient and onset of symptoms play an important role in the initial assessment. A young patient with sudden onset of symptoms accompanied by other neurologic complaints may warrant further workup for underlying neurologic disease such as multiple sclerosis. Past medical and surgical history are noted because these may be contributing factors to the patient’s problems. OAB symptoms can often be traced to other comorbidities such as poorly controlled diabetes or history of a stroke. UR can be preceded by radical pelvic surgery or a long-standing history of voiding dysfunction.

Physical examination focuses on evaluation of concurrent anatomic abnormalities such as demonstrable pelvic organ prolapse and/or stress urinary incontinence (SUI) during a supine stress test in female patients. These issues can complicate successful treatment of urgency by SNM, which is rendered moot by profound SUI. Saddle sensation should be evaluated and anal sphincter tone assessed. Testing of the bulbocavernosus reflex evaluates the S2–S4 pelvic nerve root. Absence suggests an underlying neurogenic process that may need further evaluation (8). In male patients, a digital rectal exam can suggest a prostatic etiology for outlet obstruction. Initial evaluation tests include a urinalysis to screen for infection and a postvoid residual in patients who complain of incomplete emptying. A 3-day voiding diary is very useful in identifying patients who are candidates for SNM as well as educating patients on their fluid intake and habits. This also serves as an objective measure of urgency and incontinence. If the patient performs clean intermittent catheterization, a voiding/catheterization diary gives a baseline of the patient's symptoms as well as the patient's storage capacity. Urodynamics is reserved for cases where mixed urinary incontinence and abnormal compliance in a neurogenic bladder confound the diagnosis. Fluorourodynamics evaluates whether the patient has obstructive voiding amenable to surgical correction versus non-neurogenic voiding dysfunction, which may be ameliorated by pelvic floor training or SNM. Cystoscopy is selectively performed if there is a concern for bladder outlet pathology.

INDICATIONS FOR SURGERY

After a thorough workup, patients diagnosed with either refractory UUI, urgency-frequency or nonobstructive UR can be considered candidates for SNM. Contraindications exist for SNM. Although SNM can be done in short outpatient staged procedures or with an in-office peripheral nerve evaluation followed by one-stage implantation, all patients should be cleared for surgery. Candidates for therapy must be able to lie in the prone position throughout the duration of the procedure. SNM is not currently recommended in patients who need to undergo spinal magnetic resonance imaging (MRI) due to the theoretical risk of lead heating/dislocation and/or implantable pulse generator (IPG) torquing/malfunction/displacement. Nevertheless, a retrospective review of nine patients who underwent 15 MRIs including that of the lumbar spine showed no adverse effects to MRI interpretation or device functioning (9). Although this review had similar results to other studies, SNM placement in patients with known neurologic disease necessitating frequent spinal MRIs cannot be advocated at this time. Magnetic resonance (MR) of the head at 1.5 Tesla is conditionally approved in patients with InterStim. MR studies should not be performed in patients who are in the testing phase (10). Given the unknown risk of teratogenicity, SNM is relatively contraindicated during pregnancy. Patients with a functioning SNM should have their IPG turned off for the duration of their pregnancy. All patients should have cognition which allows them to properly operate the iCon controller. Performing a mini-mental status exam or clock test to evaluate baseline cognition can be helpful in evaluation for candidacy. Lastly, complex anatomy or prior history of surgery or trauma in the area of the sacral foramina may preclude a patient from being a candidate for lead placement.

ALTERNATIVE THERAPY

All patients are counseled on therapy options based on their initial complaint. For those with UUI or urgency-frequency, first-line therapy consists of behavioral modification. Second-line therapy for OAB includes pharmacotherapy. Alternative third-line therapy options such as percutaneous tibial nerve stimulation (PTNS) and onabotulinumtoxinA injection into the detrusor should be discussed. PTNS is a minimally invasive stimulation of the posterior tibial nerve with weekly 30-minute sessions for an initial period of 12 weeks. OnabotulinumtoxinA has been approved for use in both idiopathic and neurogenic detrusor overactivity patients. For the patient who has failed all therapy options, augmentation cystoplasty exists as a fourth-line treatment. Treatment options for patients with nonobstructive UR include intermittent catheterization or surgical management with urinary diversion when appropriate (11). Conservative treatment with fecal incontinence includes physical therapy with biofeedback. For the refractory patient, surgical management including sphincteroplasty, artificial sphincter, and SNM can be considered as other options.

SURGICAL TECHNIQUE

The implantation of SNM has evolved with time. In 2002, the tined lead was introduced, which obviated the need for larger incisions to anchor the lead to the thoracolumbar fascia.(Fig. 47.1) The IPG was originally placed in the lower anterior abdominal wall and now is placed in the gluteal region. The size of the InterStim II 3058 IPG is also smaller with the trade-off of decreased battery longevity (Fig. 47.2).

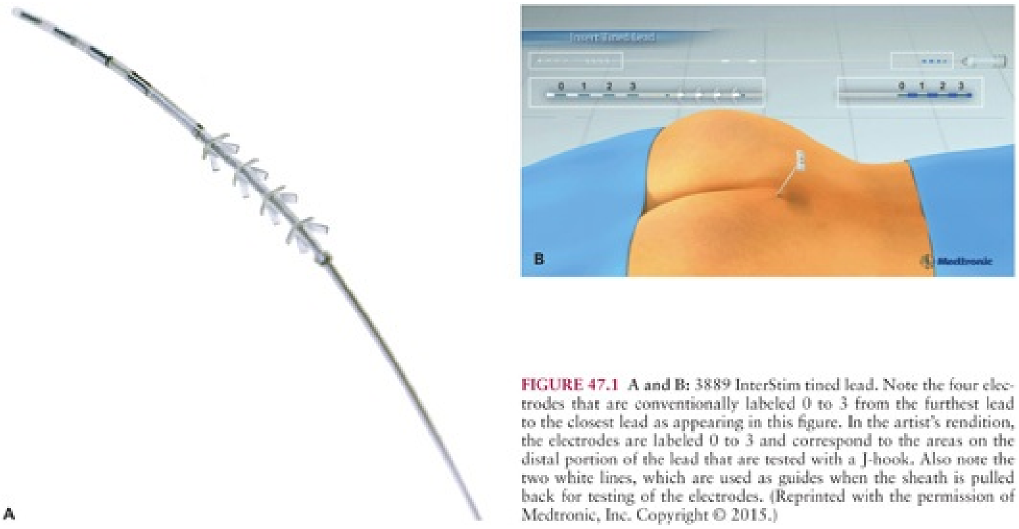

FIGURE 47.1 **A and B:** 3889 InterStim tined lead. Note the four electrodes that are conventionally labeled 0 to 3 from the furthest lead to the closest lead as appearing in this figure. In the artist's rendition, the electrodes are labeled 0 to 3 and correspond to the areas on the distal portion of the lead that are tested with a J-hook. Also note the two white lines, which are used as guides when the sheath is pulled back for testing of the electrodes. (Reprinted with the permission of Medtronic, Inc. Copyright © 2015.)

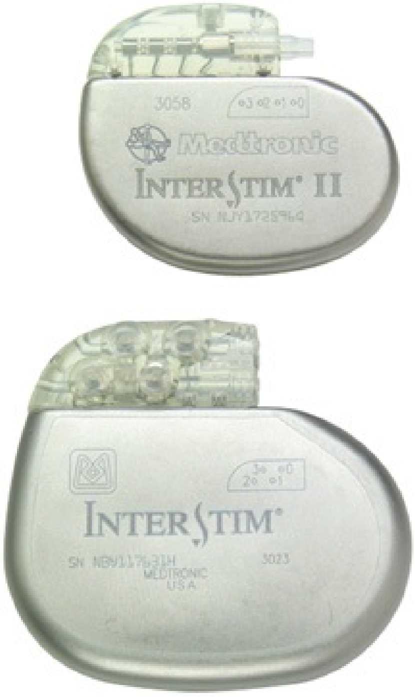

FIGURE 47.2 InterStim I IPG (*bottom*) versus the current InterStim II IPG (*top*). Although smaller in size, the InterStim II IPG has a shorter battery life. (Reprinted with the permission of Medtronic, Inc. Copyright © 2015.)

SNM involves test stimulation and then implantation. This is one of the benefits of SNM as a therapeutic option. The patient tests the therapy prior to proceeding to implantation. The test stimulation can be done with either peripheral nerve evaluation (PNE) or implantation of a tined lead. The PNE involves placement of a nonpermanent lead followed by a single operation for permanent lead and IPG implantation. The staged operation consists of test stimulation with a tined lead placed in the operating room and then subsequent IPG implantation if successful.

Peripheral Nerve Evaluation Test Stimulation

PNE is an office-based procedure that can be used to test patients prior to implantation of the tined lead and IPG during a single surgery. PNE offers the evaluation of efficacy without the risks and inconvenience of two separate operating room anesthetic procedures. In addition, the standard placement of a PNE lead in the right and left foramen during the trial allows the surgeon to test both sides. Efficacy needs to be seen on only one side to lead to single-stage implantation. Historically, initial permanent lead placement required a morbid cutdown procedure to the thoracolumbar fascia or sacrum for securing the lead. Patient selection is important prior to justifying PNE versus a staged implantation due to the increased risk of lead migration with a non-tined lead and shorter trial period. The PNE lead is placed under local anesthetic. Fluoroscopy may or may not be used. Sensory and motor responses are evaluated. Given the non-tined lead, the trial is set for 6 to 7 days versus the longer trial period in a staged evaluation. Although up to 50% of patients will have a successful PNE trial, numerous patients fail either due to lead migration, accidental lead discontinuation, inappropriate length of trial, or inability to perform complex programming (12). Thus, patients who fail PNE or have equivocal results may still undergo a test stimulation with a tined lead.

We prefer to perform PNE in our office setting with local anesthetic. The patient is asked to shower with a chlorhexidine scrub the night before. In the office, the patient changes into a gown and is placed in the prone position with flexion at the hips and knees. A towel roll or support can be used to aid with flexion. The lower back, presacral area, and buttock are prepped with a skin prep solution. The patient is then draped with the anus exposed to evaluate for bellows. If the patient’s body habitus makes bellows difficult to observe, taping of the buttocks prior to prepping can aid with visualization. It is often useful to have an assistant in the room to help the patient and the surgeon. A grounding pad for the lead is placed on the calf or heel of the patient. The red cord from the screener cable is connected to the grounding pad. The white connector to the screener cable is connected to the screener box. The black plug of the screener cable is then connected to the patient cable.

Localization of the S3 Foramen

The procedure can be performed with or without fluoroscopic localization. If no fluoroscopy is used, palpable bony landmarks include the tip of the coccyx, the sciatic notches, and the curve of the sacrum. The approximate location of the S3 foramen is found by measuring 9 cm cephalad from the tip of coccyx in the midline and 2 cm lateral from the midline to identify the foramen on either side. An additional mark is made at a level 11 cm from the tip of the coccyx because this will allow for a perpendicular entry of the finder needle to the sacrum and optimal positioning of the finder needle through the S3 foramen (Fig. 47.3). Another method of localizing the S3 foramen is based on the sciatic notch. The S3 foramen is typically at the level of the sciatic notch and a line can be drawn from the left and right notches if they can be palpated. The sacrum defines midline and the foramina should be 2 cm lateral on either side of the midline. A less reliable landmark that can be used for localization is the curve of the sacrum. Theoretically, the sacral crest is S4. Thus, 2 cm cephalad of S4 would be the plane for the S3 foramen.

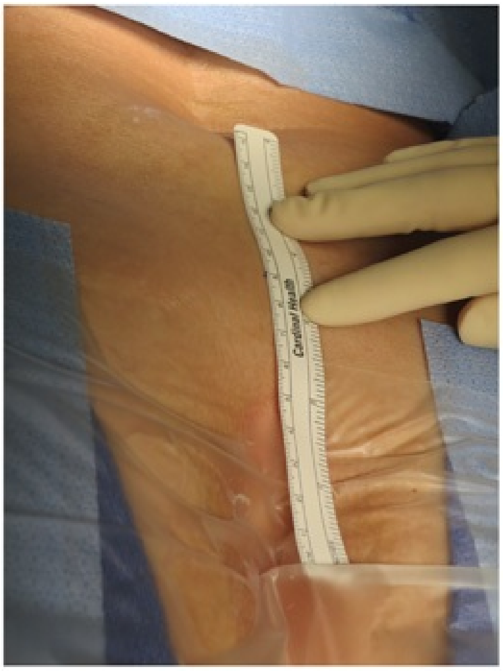

FIGURE 47.3 Using landmarks such as the anal verge to estimate the location of the S3 foramen. This ruler demonstrates the 9 and 11 cm marks measured out midline from the anal verge.

If fluoroscopy is used during the procedure, a “cross-hair” technique has been described by Chai and Mamo (13). In an anteroposterior (AP) view, the inferior border of the sacroiliac joints is identified. A foramen needle is placed over this area. The spinous process is then marked midline with a directional guide (Fig. 47.4). A mark is made, and the foramen should be 2 cm lateral to the mark on either side. The finder needle should be inserted into the dermis above this marking to achieve an angle of entry perpendicular to the bony plate. This equates to a 60-degree angle placement through the skin. In contrast, if the finder needle were placed directly at the mark on fluoroscopy, a 90-degree angle through the skin would correlate to a more difficult entry into the foramen given the curve of the sacrum (Fig. 47.5).

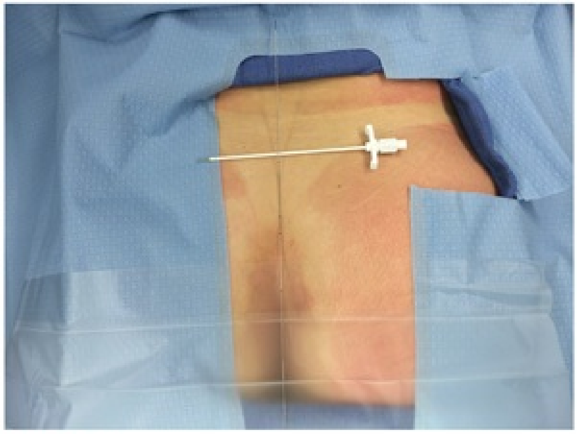

FIGURE 47.4 Cross-hair technique demonstrated with placing the radiopaque directional guide in the midline and either a finder needle or obturator/sheath in the transverse direction sitting on the most inferior border of the sacroiliac joints. The S3 foramen should be 2 cm lateral of midline on either side.

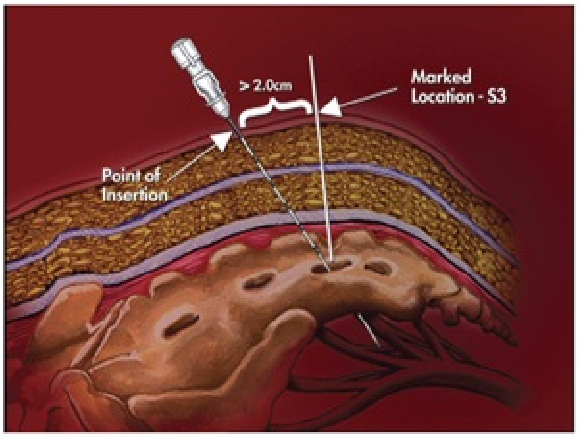

FIGURE 47.5 Proper insertion and angle of the finder needle in the S3 foramen. A 60-degree angle enables the needle to properly enter the S3 foramen given the curve of the sacrum versus a 90-degree angle that may lead to a less than optimal placement of the lead next to the sacral nerve as it exits the foramen. (From Medtronic, Inc. Copyright ©2014, with permission.)

Placement of Peripheral NerveEvaluation Lead

Local anesthetic is used, typically lidocaine without epinephrine with or without bicarbonate buffering, at the general site of insertion of the foramen finder needle on the left and right sides. A wheal is raised and subcutaneous infiltration is performed. Care is taken not to anesthetize the foramen. Foramen finder needles come in 3.5- or 5-inch lengths and are chosen based on body habitus. The finder needle is introduced. The finder needle is held like a dart between the index and thumb fingers during placement through the skin and subepithelial tissues. If the needle hits bone, it is walked down the sacrum until it drops into the foramen. A fluoroscopic image is taken and then stimulation is applied to test for sensory and motor responses. Sample settings are displayed for the screener box (Table 47.1). If motor responses suggest too high or low of a foramen placement, the finder needle is simply brought back to the subdermal level and walked to the appropriate S3 foramen in the same line. Difficult cannulation of the foramen can be aided by stepping back from the patient's side and assessing the needle entry from the feet looking toward the head. From this vantage point, proper medial to lateral orientation can be ensured. Localization of the S3 foramen can also be aided with a cross table lateral image to identify the relation of the needle to the hillock.

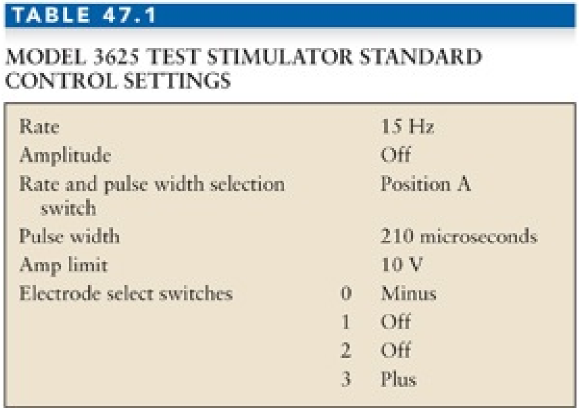

TABLE 47.1

MODEL 3625 TEST STIMULATOR STANDARD CONTROL SETTINGS

Rate		15 Hz
Amplitude		Off
Rate and pulse width selection switch		Position A
Pulse width		210 microseconds
Amp limit		10 V
Electrode select switches	0	Minus
	1	Off
	2	Off
	3	Plus

A response is tested by applying the J hook of the patient testing cable to the noninsulated portion of the finder needle. The amplitude on the screener box is gradually increased until stimulation is localized and a motor response is visualized. The proper motor response for S3 nerve root stimulation is ipsilateral plantar flexion of the big toe and levator contraction resulting in anal bellows (Table 47.2). Sensory localization should be described as a fluttering or tugging sensation in the rectum, vagina or labia (female), or penis or scrotum (male). The procedure is repeated for the contralateral S3 foramen. Once proper S3 placement is confirmed, the lead is placed. This is performed by removing the stylet in the finder needle while holding the position constant at the skin. The temporary lead and stylet are passed through the finder needle. Proper depth is achieved by delivering the temporary lead down to the first marker (Fig. 47.6). The lead is tested again to assess for proper response. The finder needle and lead stylet are then removed while keeping the lead in place. The same is done for the contralateral foramen. The leads are then secured to the patient with a clear adhesive dressing. The exposed ends of the leads are tamped into the grounding pads, which are affixed to the patient's back. The test stimulator cords are then connected to the grounding pads (Fig. 47.7).

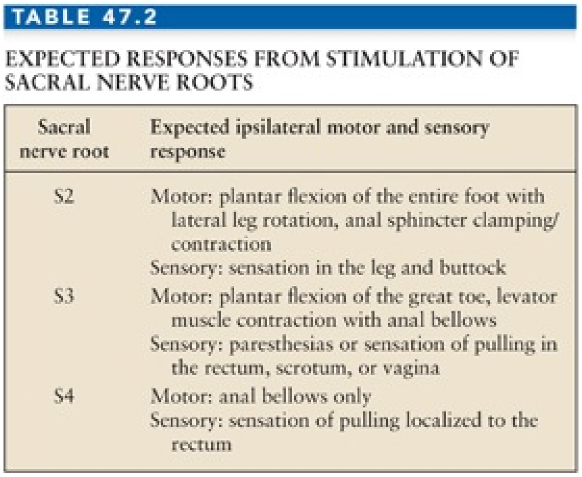

TABLE 47.2

EXPECTED RESPONSES FROM STIMULATION OF SACRAL NERVE ROOTS

Sacral nerve root	Expected ipsilateral motor and sensory response
S2	Motor: plantar flexion of the entire foot with lateral leg rotation, anal sphincter clamping/contraction Sensory: sensation in the leg and buttock
S3	Motor: plantar flexion of the great toe, levator muscle contraction with anal bellows Sensory: paresthesias or sensation of pulling in the rectum, scrotum, or vagina
S4	Motor: anal bellows only Sensory: sensation of pulling localized to the rectum

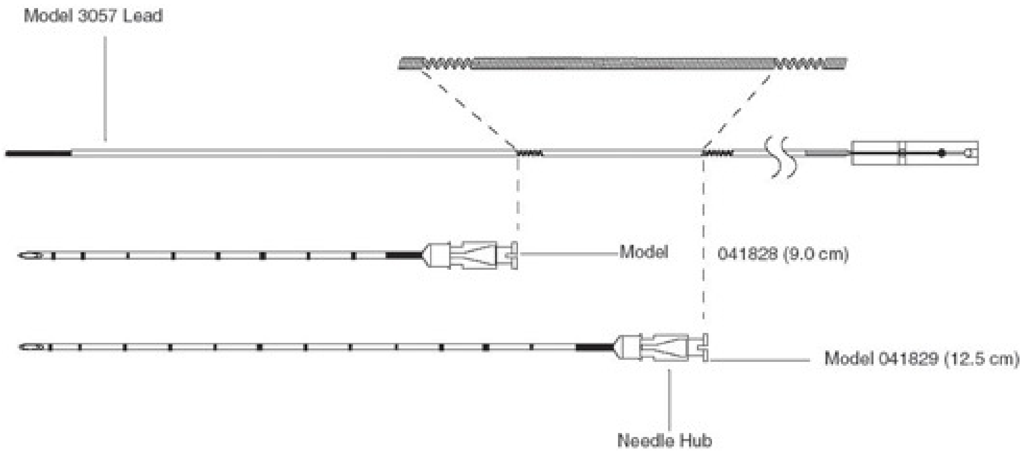

FIGURE 47.6 The PNE test lead is shown here next to the 9 and 12.5 cm finder needles. Note the indicators on the PNE lead which demonstrate proper depth placement of the temporary test lead. These also correspond to the length of finder needle being used.

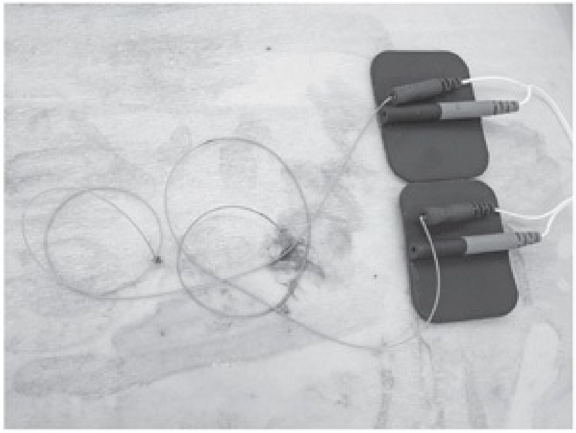

FIGURE 47.7 Once the PNE test lead is in place, dressing is applied over the excess test cable. The test cord simulator is attached to the external ground pad and the test stimulator/screener box is turned on and placed on the patient's clothing during the test period. (Reprinted with the permission of Medtronic, Inc. Copyright © 2015.)

Stage I Tined Lead Placement

During a stage I tined lead placement, the patient is brought into the room and positioned like a PNE. They are placed in the prone position with a pillow or roll under the hips and/or chest for comfort and optimal positioning. An intravenous antibiotic is given prior to the start of the procedure such as a cephalosporin, macrolide, and/or aminoglycoside. Anesthesia consists of either a general anesthetic or monitored anesthesia care with local anesthetic. If a general anesthetic is used, long-term paralytics should not be administered because motor responses need to be assessed for proper foramen placement. The patient is then prepped and draped. The bottom portion of the drape can be cut or placed below the level of the anus to allow for viewing of a bellows reflex. A plastic drape is then placed over the anus to keep it separated from the rest of the clean procedure while allowing visualization of the bellows when necessary. The patient's foot should be exposed to monitor for great toe response.

After administration of local anesthetic, a finder needle is used to enter the S3 foramen and obtain a confirmatory bellows and toe response. Errant needle placement through S2 or S4 can catch the S3 nerve roots and give a false-positive bellows and toe response.

Once the proper motor and sensory response is obtained and radiographic imaging demonstrates proper placement, the inner stylet of the finder needle is removed and a directional guide is placed. Advancement of the directional guide stops when resistance is met. A fluoroscopic image is obtained to ascertain proper depth. The finder needle sheath is removed over the guide while keeping the directional guide in place. An incision is made completely through the dermis and an introducer sheath is placed over the directional guide. Fluoroscopic imaging is obtained to ensure that the introducer sheath radiopaque marker is midway through the bone. The tip of the sheath should be just past the ventrum of the sacral spine. The package with the tined lead should then be opened and ready on the field for prompt placement. The obturator and directional guide are then removed while holding the sheath in place. Any delay in placing the lead could increase bleeding, which could cause decreased motor or sensory response during testing. Tined leads currently are packaged with a straight stylet, although a curved one is included in the kit. The theoretical benefit of a curved stylet is the ability to follow the natural trajectory of the sacral nerve root as it exits the sacrum and increase lead and nerve root contact for maximal efficacy. A randomized prospective crossover study with 40 patients from Irvine, California, demonstrated consistently lower amplitude stimulation with placement of the lead with a curved stylet versus a straight stylet (14).

Electrodes on the tined lead are conventionally referred to as 0 (the most distal electrode) through 3 (the most proximal). The tined lead is optimally placed to position the 2 and 3 electrodes straddling over the ventral surface of the sacrum (Fig. 47.8). The sheath is brought back to the second white line on the tined lead to expose the electrodes but to leave the tines protected (Fig. 47.9). Testing is performed at each electrode. Both motor and sensory responses are recorded. The goal during optimal placement of the lead is to obtain responses at all four electrodes at low amplitudes. Once the surgeon is satisfied with lead placement, the sheath and stylet are discontinued while the lead is held in place. When the sheath passes over the second white line, the tines are engaged and the lead cannot be easily repositioned. Fluoroscopic equipment can then be taken away after a final image is taken in the cross table lateral and AP orientations (Figs. 47.10 and 47.11).

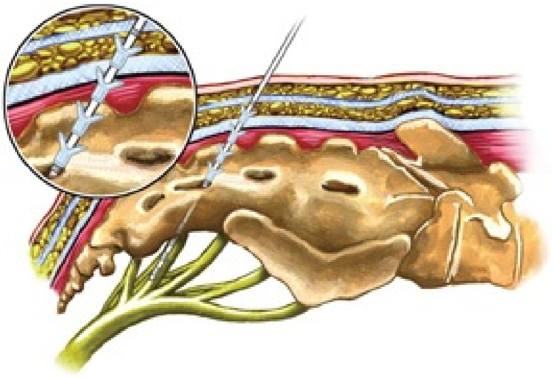

FIGURE 47.8 Lateral anatomic view of a tined lead during stage I testing. The electrodes of the lead follow the nerve as it exits the S3 foramen. The second and third electrodes straddle the anterior bony plate and the tined leads anchor into the thoracolumbar fascia, the multifidus muscle layer and the sacral periosteum. Note that given the proximity of the nerve roots, errant entry into either the S2 or S4 foramen can cause a false-positive motor response by stimulating the S3 nerve root. (Reprinted with the permission of Medtronic, Inc. Copyright © 2015.)

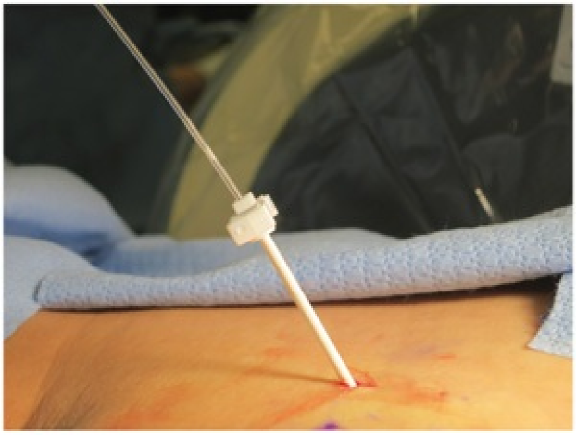

FIGURE 47.9 Placement of tined lead during stage I testing. Two markers indicate the depth of the lead. When testing the electrodes of the lead, the sheath needs to be move back to the second marker to expose the electrodes. (Reprinted with the permission of Medtronic, Inc. Copyright © 2015.)

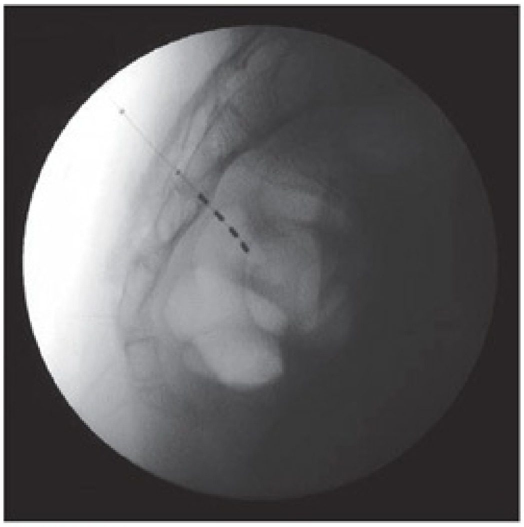

FIGURE 47.10 Lateral fluoroscopic view of a tined lead. Proper lead placement can be fluoroscopically confirmed by evaluating the iliac shadow and the S3 hillock in addition to motor and sensory responses. Note the straddling of the anterior plate with electrode 2 and 3 and also the orientation of the lead suggesting lateral deviation along the path of the nerve root. (Reprinted with the permission of Medtronic, Inc. Copyright © 2015.)

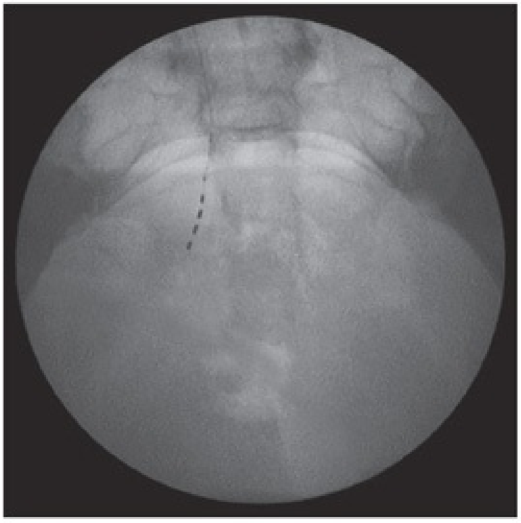

FIGURE 47.11 AP fluoroscopic view of a tined lead. Proper lead placement can be confirmed fluoroscopically in the AP position by evaluating the lead position in relation to the sciatic notches, the inferior border of the sacroiliac joints, and the medial to lateral placement of the lead. Sensory and motor responses confirm proper placement of the lead. (Reprinted with the permission of Medtronic, Inc. Copyright © 2015.)

A transverse incision is made in the patient’s left or right upper buttock below the belt line, approximately 3 to 5 cm below the superior iliac crest. This incision is extended into the subcutaneous tissues and a space is developed to accommodate the connection between the permanent tined lead and the percutaneous extension wire. This incision will also be the final pocket site for the IPG if the testing phase is successful. The external portion of the tined lead is then tunneled to the medial portion of this site through the subcutaneous tissue using the tunneling device. The lead is cleaned off with sterile water and attached to the percutaneous extension wire with the set screws. A plastic boot is placed over the set screws and secured using nonabsorbable nonbraided suture. The percutaneous extension wire is then tunneled to an area on the contralateral buttock and brought through the skin. The tunneling of the percutaneous lead across the back to the contralateral side minimizes bacterial seeding of this pocket. Care is taken while tunneling the lead so as not to injure the lead at its original insertion point. Also, an exit site should not be so distal from the pocket that the tunneling device sheath does not reach. The directional guide can be used as a pusher to move the percutaneous lead wire through the sheath to reach the contralateral side.

At this point, the upper buttock pocket is irrigated with sterile water, bacitracin, or Betadine solution (saline should not be used) and then closed in a two-layer fashion with an interrupted 2-0 absorbable layer in the subcutaneous tissues and a running 4-0 absorbable suture layer for the skin. The wound should be closed meticulously with awareness of the lead at all times. The skin is dressed with either cyanoacrylate glue or adhesive strips. The percutaneous extension wire is connected to the external test simulator cable. Patient instructions include no full-body showers that would include the area where the percutaneous extension wire exits the skin and no strenuous activities that could dislodge the lead. Patients are typically discharged home on a short antibiotic regimen to cover skin flora.

Medtronic has introduced a new external neurostimulator that can wireless communicate with the patient controller for stage I testing. While the prior "brown box" test stimulator can still be used for the testing phase, the new Verify system has the theoretical advantage of not tethering the patient to the test stimulator box, a decreased chance of accidental lead discontinuation and ease to change program stimulation with a graphical user interface. (Fig 47.12)

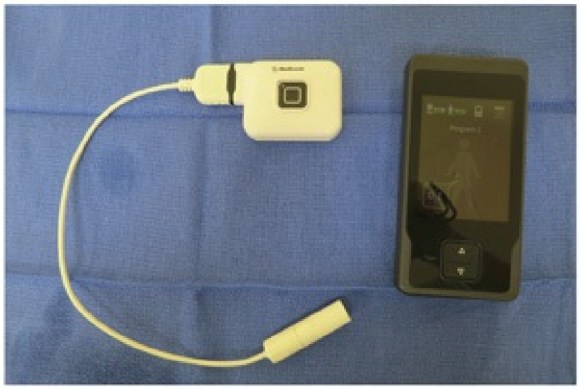

FIGURE 47.12 The Verify system can be used during stage I testing. The external neurostimulator (ENS) communicates wirelessly with the patient controller. Theoretically patients are not tethered to their control box which can decrease the incidence of accidental lead displacement and patient discomfort.

The test stimulator is programmed in postanesthesia recovery, and patients record their improvement in symptoms by maintaining a voiding diary during the trial period. The patient proceeds to a stage II procedure if they have a 50% improvement in symptoms from baseline as evidenced by their records.

Stage II

After a successful first stage test stimulation, the patient is brought to the operating room for a stage II IPG implantation. The stage II procedure is shorter than a stage I procedure because the tined lead is already in place. Although no sensory/motor responses are tested during stage II implantation, the patient is positioned and draped similar to a stage I procedure in case the lead is inadvertently dislodged. Perioperative antibiotics appropriate for device implantation are given and anesthesia is administered. Adhesive remover is used to clean the skin of prior residual tape. The presacral and buttock region are prepped and draped. The prior incision in the upper buttock area is opened in a medial to lateral fashion with extension of this incision laterally if needed to accommodate the IPG. Prior suture material encountered during the dissection is removed. Care is taken during subcutaneous dissection to avoid severing the lead. The percutaneous extension wire, boot, and lead are found and the suture securing the boot is cut. The plastic boot is removed and the set screws are loosened. The miniscule set screws can dislodge out of the percutaneous extension wire if loosened too much. The percutaneous extension wire is cut, the lead connector is removed from the incision, and the external tail can be removed after the drapes have been pulled off and the incision has already been closed.

The subcutaneous pocket is made deep and wide enough to fit the IPG so it will lie flat but not rotate freely. The pocket depth should be adequate to prevent erosion and provide acceptable cosmesis. The skin should close easily without tension. The area is irrigated with sterile water, bacitracin, or Betadine solution, and careful cautery is used to ensure hemostasis. An IPG such as the InterStim II is opened and connected to the lead wire with a set screw. The IPG is placed in the pocket with the etched writing facing up and the lead protected behind the IPG. After ensuring proper IPG placement, the IPG is turned on with an external test device and impedances are tested to ensure proper functioning of the system. Once completed, closure of the wound is performed with two layers using 2-0 and 4-0 absorbable suture. The wound is then dressed. Patients are discharged with instructions to avoid heavy or strenuous activity and directions for using the iCon patient controller. A short course of antibiotics and pain medication are prescribed upon discharge.

Single-Stage Implantation

After a successful PNE trial, patients are brought back for a single-stage implantation. PNE wires are usually discontinued in the office prior to single-stage implantation. Single-stage implantation then follows the procedure of stage I and stage II implantation but instead of connecting the tined lead to a percutaneous extension wire, it is directly connected to the IPG.

OUTCOMES

Complications

Historically, rates for safety of SNM included patients who had undergone prior lead implantation with now obsolete techniques such as anchoring the lead to the thoracolumbar fascia or implantation of the IPG in the lower abdomen. In 2000, long-term results were published on a prospective nonrandomized cohort who underwent implantation of the InterStim system (lead and generator). Adverse events were then pooled across a total of 581 patients who underwent SNM testing. Adverse events were seen in 18.2% of the total 941 test stimulations performed with the most common being related to lead migration (11.8%). Of the 219 patients who underwent implantation, pain at the neurostimulator site was the most commonly observed adverse effect at 12 months (15.3%). Infection rate was 6.1%. Surgical revisions of the implanted neurostimulator or lead system were performed in 33.3% of cases (73 of 219 patients) to resolve an adverse event. These included relocation of the neurostimulator because of pain at the subcutaneous pocket site and revision of the lead for suspected migration. Explantation of the system was performed in 10.5% for lack of efficacy (15).

Al-zahrani et al. (16) also evaluated their 14-year experience with SNM from 1994 to 2008. The patient population predominantly involved patients with bladder pain syndrome (47.9%). A total of 96 SNM devices were implanted. There were no infections noted which they attributed to a predominantly PNE to a single-stage procedure for most patients. For the entire cohort, the revision rate was 39%. When evaluating UUI and retention patients separately, the revision rate was 32% and 56%, respectively. Symptom deterioration was the main reason for revision in both UUI (64%) and retention (55%) cases. Of those patients with UUI and UR, they noted a 14.7% and 12.5% explantation rate, respectively. The most common reason for explant in patients with UUI was for painful stimulation three-fifths (60%) of cases. The reason for explant in UR patients was loss of efficacy. Given that the technique changed during the study period, there was a significant decrease in lead revision after use of the tined lead from 50% down to 31% (16).

Marcelissen et al. (17) reported on safety and adverse events in patients undergoing SNM with a tined lead. A total of 64 patients underwent SNM implantation. Three patients had hematomas that were treated with postoperative antibiotics and observation. One patient developed a wound infection requiring explantation. The total explantation rate was 10.9%. Twenty-one patients needed revisions (33% reoperation rate). Seventeen patients (27%) reported pain with the predominant form being pain at the site followed by bothersome stimulation. Nine patients (53%) had reprogramming, which alleviated their pain.

Hijaz and Vasavada (18) reported on a single institution's results on 161 patients in a larger contemporary series dealing with only tined lead implantations. By following their previously reported troubleshooting algorithm, they retrospectively analyzed their patients from 2002 to 2004. After second-stage implantation, the revision rate was noted to be 26/161 patients (16.1%) with the majority of revision performed due to decreased response (17/26 patients). The explantation rate was 17/161 patients (10.5%) with reasons being infection (8/17 patients) or failure to maintain function (9/17) (19).

Results

Although the original outcomes regarding SNM were derived from two randomized studies dealing with patients who had idiopathic urgency-frequency and UUI, since 2007, multiple studies have been published regarding efficacy of SNM (20,21). Most of these have been prospective nonrandomized studies.

Van Kerrebroeck et al. (22) published their results of a 5-year prospective post-approval multicenter study in 2007. There were 163 total patients included in their study. The majority were female and had an indication of UUI. There were 128 of the enrolled patients who were part of an earlier randomized controlled study regarding the efficacy of InterStim (MDT-103). At 5 years follow-up, 105 patients completed follow-up visits and 87 patients completed voiding diaries. Clinical success rate was defined as a 50% or greater improvement from baseline. At 5 years, this remained statistically significant for multiple variables including UUI episodes per day (58% of patients), number of voids per day (40% of patients), and number of catheterizations per day in UR patients (58% of patients) (22).

Marcelissen et al. (17) evaluated the long-term results of tined lead placement for SNM. A total of 92 patients were included in this single-center observational study and 70% were implanted. The majority were female with an indication of OAB wet. Mean follow-up was 51 months with a success rate of 64%. For OAB wet patients, mean leakage per day and pads per day was observed to significantly decrease (7.7 ± 5 to 4.0 ± 3.8 leakage per day, 4.6 ± 3 to 2.3 ± 2.8 pads per day) (17).

Cameron et al. (23) evaluated successful sacral nerve test stimulation by evaluating medical claim data from a 5% sample of Medicare beneficiaries and compared this to a sample of private insurance patients working for large Fortune 500 companies. A total of 358 patient records were evaluated in the Medicare group versus 266 with private insurance. The majority of patients were white, female, and had a diagnosis of OAB. Success was defined by implantation of IPG. In the Medicare population, 45.8% of the PNE patients went on to IPG placement compared to 24.1% in the privately insured group. For staged procedures, 35.4% of Medicare patients received an IPG compared to 50.9% in the private insurance group. Overall success was 39.9% and 49.1% in the Medicare and privately insured populations, respectively. The only variable that was consistently associated with higher rate of success in both groups was female gender. Age did not consistently predict success. Given this was a large health care claim–based review, their study was limited by not knowing whether patients did not undergo IPG placement based on lack of efficacy with stage I trial versus not wanting to proceed with implantation. Also, they mention that their data spans a 10-year period when the technology and efficacy may have changed. Multiple providers with different experiences were also included which could have confounded results (23).

The most recent multicenter randomized trial comparing SNM to standard medical therapy enrolled a total of 147 patients. Thirty-eight sites were included in the study. The InSite trial evaluated the 6-month success rate for these two groups. Ninety-three percent of the patients were female and were diagnosed with either UUI or urgency-frequency and had failed at least one anticholinergic medication. Of the 70 patients who were randomized to SNM, 51 (72.9%) patients went on to implantation. By intention to treat analysis, 61.4% had a 50% or greater improvement in symptoms from baseline in the SNM group versus 41.6% in the standard medical therapy group. Of the 51 patients who were implanted, 76.5% had a clinical success rate of 50% or greater improvement in symptoms at 6 months. The significant improvement in symptoms was also mirrored in International Consultation on Incontinence Questionnaires (ICIQ) domain improvements in concern, coping, sleep, and social domains (24). Twelve-month data evaluating the prospective multicenter portion of this arm revealed a responder rate of 85%, 79%, and 59% for OAB, UUI, and urinary frequency, respectively (25).

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CHAPTER 48 SURGICAL TREATMENT OF PELVIC ORGAN PROLAPSE

ARIANA L. SMITH, POLINA REYBLAT, AND JA-HONG KIM

Pelvic organ prolapse (POP) is a prevalent women's health issue affecting nearly 40% of postmenopausal women (1). The etiology of POP is multifactorial, with most cases being attributable to genetics (2), followed by aging, white race, obesity, parity, hormonal status, birth and surgical trauma, smoking, chronic constipation, chronic cough, and family history of prolapse (3,4). It is estimated that surgical demand related to POP will increase by 46% over the next four decades (5).

For any pelvic reconstructive surgeon attempting correction of vaginal prolapse, it is paramount to understand the relationship between pelvic floor anatomy and function in order to optimize both objective and subjective outcomes. For this reason, we will begin this chapter with detailed review of female pelvic anatomy and musculofascial support, with emphasis on the integral structures that allow normal voiding and defecatory function. We will then focus on the various surgical techniques used to correct the defect categorized by anterior, apical, and posterior compartments.

ANATOMY OF PELVIC SUPPORT

Conceptually, the vaginal canal can be divided into three compartments that have distinct anatomic structures: (a) the anterior compartment, which includes the urethra, bladder neck, and bladder; (b) the apical compartment, which includes the uterus and cul-de-sac after hysterectomy; and (c) the posterior compartment, which includes the rectum, anal canal, and perineum. These compartments are functionally and anatomically dependent as they share the same pelvic floor foundation. Structurally, the vaginal and pelvic support starts with a framework of bones and ligaments that are lined with fascia and muscles. These components are intimately related and in some cases are continuations of each other, especially in the case of ligaments and fascia.

The Pelvic Diaphragm

Bones

The framework of the pelvic floor is provided by the bony structures, including the pubis, ilium, ischium, sacrum, and coccyx. The pelvic bones create a diamond shape, with the pubic symphysis and coccyx at the apices and the ischial tuberosities dividing the diamond into anterior and posterior compartments. The anterior or urogenital triangle contains the clitoris, urethra, and vaginal vestibule. The posterior or anal triangle contains the anal canal and anal sphincter. The pubic rami, ischial spines, and sacrum are important anchoring points of muscular and fascial structures in the pelvis (6).

Ligaments and Fascia

The name *ligament* has been given to what are truly dense condensations of connective tissue in the pelvis. The structures commonly called fascia are sheets of connective tissue separating the vagina from the urethra, bladder, cervix, and rectum (7). The fascia overlying the pelvic floor musculature plays a critical role in pelvic support. Both sides of the muscle, the abdominal side and the vaginal side, are covered with fascia and have distinct nomenclature. On the *abdominal* side, it is called endopelvic fascia and represents a continuation of the transversalis fascia. On the *vaginal* side, it is named according to the structure it supports (periurethral fascia, perivesical fascia, and pararectal/prerectal fascia). These two components of fascia join together to form the ligaments that give support to the various pelvic organs.

Pubourethral Ligaments. The pubourethral ligaments anchor the urethra anteriorly to the inferior ramus of the pubic symphysis (Fig. 48.1). They also divide the urethra into proximal and distal halves, with the proximal, intra-abdominal portion responsible for passive, involuntary continence. The midportion, or the striated external sphincter, is responsible for active, voluntary continence.

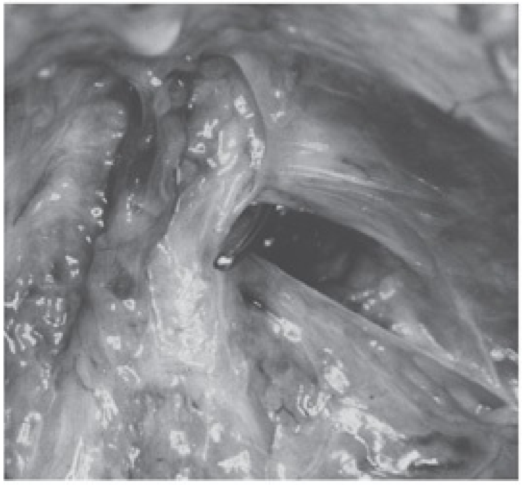

FIGURE 48.1 Abdominal view of the pelvis in a cadaver. The retropubic space has been entered from the vaginal side, detaching the urethropelvic ligaments from the lateral pelvic wall and exposing the pubourethral ligament.

Urethropelvic Ligaments. The urethropelvic ligaments are condensations of periurethral fascia and endopelvic fascia that provides anatomic support of the bladder neck and proximal urethra to the pelvic sidewall (Fig. 48.2). They do so by anchoring the urethra laterally to the arcus tendineus fasciae pelvis (ATFP; see the following section). The urethropelvic ligaments provide elastic, musculofascial support to the bladder outlet, thereby maintaining passive continence. Voluntary or reflex contractions of the pelvic floor increase the tensile force across these ligaments, enhancing outlet resistance and preventing incontinence. Restoration of support is important in the surgical correction of stress incontinence.

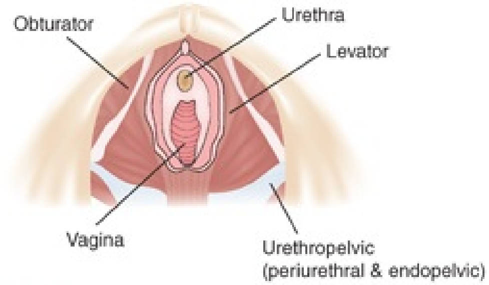

FIGURE 48.2 Urethropelvic ligaments supporting the urethra to the levator musculature of the lateral pelvic sidewall. In patients with multiple deliveries, the levator musculature is weakened and the ligament is thin, elongated, or detached from the lateral pelvic wall.

Vesicopelvic Ligaments. The vesicopelvic ligaments consist of perivesical fascia and endopelvic fascia which anchor the bladder to the pelvic sidewall. During voluntary or reactive pelvic floor contraction (i.e., contraction of the levator muscles), the ligamentous structures tighten and elevate the bladder, preventing mobility and descent into the vagina. Restoration of lateral bladder support is an important component in the correction of anterior wall prolapse, or cystocele.

Cardinal–Uterosacral Ligament Complex. The cardinal liga ments, or ligaments of Mackenrodt, are thick, triangular condensations of pelvic fascia that originate from the greater sciatic foramen and insert into the cervix and vaginal wall. They also extend to the perivesical fascia, providing support to the bladder base (Fig. 48.3). These ligaments contain numerous blood vessels branching from the hypogastrics that supply the uterus and upper vagina (6). The cardinal ligaments fuse posteriorly with the uterosacral ligaments, which stabilize the uterus, cervix, and upper vagina posteriorly toward the sacrum (Fig. 48.4). The uterosacral ligaments originate from the second, third, and fourth sacral vertebrae and insert posterolaterally into the cervix and vaginal fornices (8). The trauma of vaginal delivery can cause relaxation of the cardinal–uterosacral complex and allow descent of the cervix and uterus. It is very important to reapproximate the cardinal ligaments to the midline during hysterectomy and prolapse repair to close the gap and prevent bladder herniation.

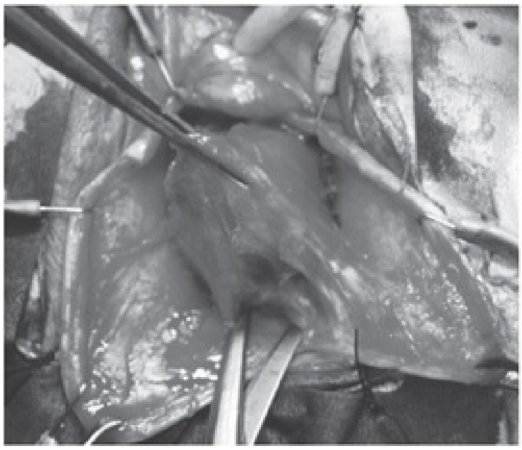

FIGURE 48.3 Dissection of the bladder wall during repair of grade IV cystocele exposes the cardinal ligaments as they attach to the bladder base.

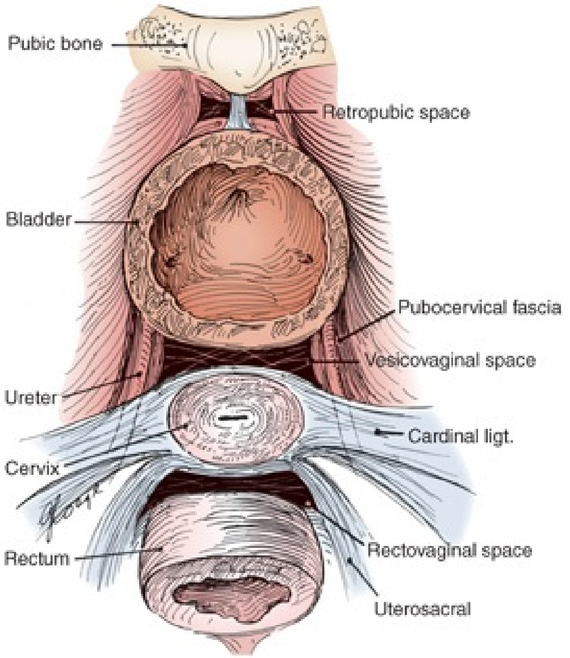

FIGURE 48.4 Uterine support and its relations to the bladder and rectum. The cardinal ligaments provide support of the cervix to the lateral pelvic wall.

Broad Ligaments. The broad ligaments attach the lateral walls of the uterine body to the pelvic sidewall and contain the fallopian tubes, the round and ovarian ligaments, and the uterine and ovarian vessels. The broad ligaments are covered by an anterior and posterior sheet of peritoneum.

Sacrospinous Ligaments. The sacrospinous ligaments span the posterior portion of the pelvic floor, from the ischial spines to the sacrum and coccyx (Fig. 48.5). The coccygeus muscle lies over the top of the sacrospinous ligament and is a very important landmark in vaginal surgery. Cephalad to the coccygeus muscle, the lumbosacral plexus spreads its fibers, which if injured can cause chronic debilitating pain. Lateral to the coccygeus muscle the pudendal nerves and vessels traverse in Alcock canal. Also in this area is the ureter, which can be injured with a suture placed too laterally during prolapse repair (9).

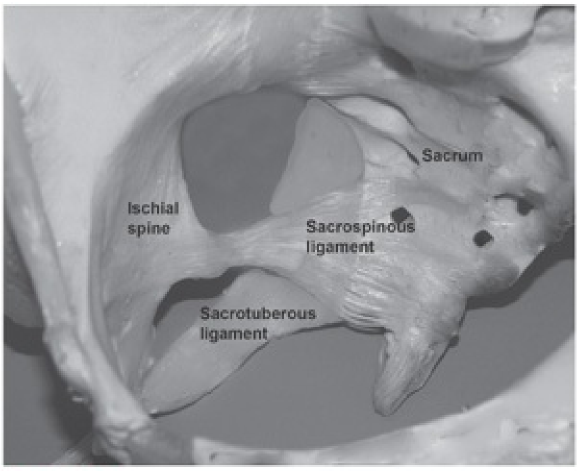

FIGURE 48.5 The sacrospinous ligament is an important area of anchoring for vaginal vault suspension.

Perineal Body. The perineal body is a tendinous structure located in the midline of the perineum between the anus and vaginal introitus. It provides a central point of fixation for the transverse perineal muscles, which extend from the ischial tuberosities laterally (10) (Fig. 48.6). The perineal body provides an additional level of support to the posterior vaginal wall and rectum, incorporating the levator ani, bulbocavernosus muscle, and transverse perineal musculature as well as the external anal sphincter. This level of support is elastic in nature, allowing distortion and recoil during childbirth and intercourse.

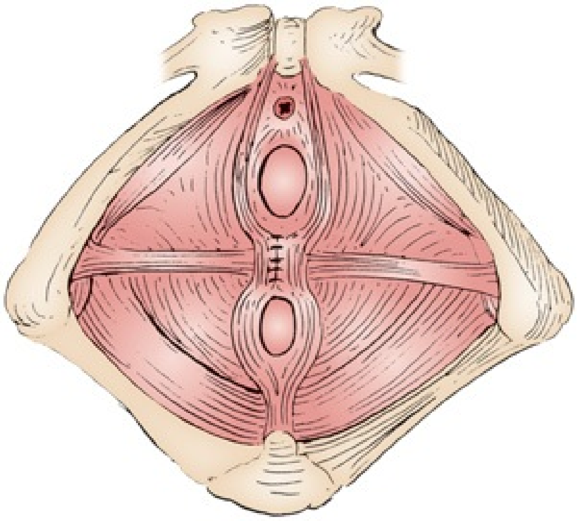

FIGURE 48.6 Repair of the perineal body. The bulbocavernosus muscle, the transverse perineal muscles, and the anal sphincter fibers are approximated to recreate the central tendon of the perineum.

Pubocervical Fascia. On the vaginal side, it is often referred to as the pubocervical fascia but can be divided into discrete areas of specialization depending on the associated organ it supports (periurethral and perivesical fascia). As a whole, the pubocervical fascia is a trapezoid-shaped continuous sheet of connective tissue support that extends from the pubic symphysis to the cervix and laterally to the ATFP (11). The fascia is fused to the bony scaffold by the cardinal ligaments laterally and the uterosacral ligaments posteriorly.

Arcus Tendineus Fasciae Pelvis. ATFP is a curvilinear condensation of pelvic fascia that arises from the obturator internus muscle and runs from the pubic symphysis to the ischial spines (Fig. 48.7). This tendinous arc of the obturator is the line of insertion of the levator muscles on the obturator fascia. This crucial structure provides musculofascial attachment for the anterior and posterior pelvic organs and anchoring point during pelvic floor reconstructive surgery.

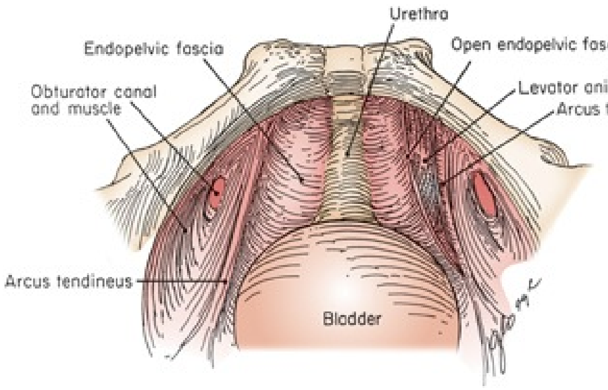

FIGURE 48.7 View of the anterior pelvis. The endopelvic fascia covers the bladder and urethra. The levator musculature is attached to the ATFP.

Prerectal/Pararectal Fascia. Prerectal and pararectal fascia extends from the cardinal–uterosacral complex to the perineal body and is sometimes referred to as the rectovaginal septum.

Musculature

The striated musculature supporting the pelvic floor is composed of the levator ani muscles and the coccygeus muscles. Together they cradle the visceral contents of the pelvis, providing dynamic support.

Levator Ani. The levator ani is composed of pubococcygeus, puborectalis, and the iliococcygeus and extends from the pubic symphysis to the ischial spines and coccyx, taking origin from the ATFP laterally. These muscle groups have overlying endopelvic fascia that allows direct attachment to the bladder, urethra, vagina, uterus, and rectum to give support during increases in intra-abdominal pressure, preventing organ descent and release of urine and stool (6).

Coccygeus. The posterior portions of the levator ani, together with the coccygeus muscle, provide a horizontal plate from the rectal hiatus to the coccyx. Resting tone of the levator ani and coccygeus, as well as reflex and voluntary contraction, acts to pull the vagina and rectum forward, closing the lumens of these structures. Re-establishing this axis is critical in maintaining sexual function as well as long-term success in prolapse surgery.

Levator Hiatus. The levator hiatus is a U-shaped midline aperture in the levator ani that allows passage of the urethra, vagina, and rectum (Fig. 48.8). These structures are supported by a fascial hammock, the urogenital diaphragm, as they exit the pelvis (12). Fibers from the pubococcygeus enter into the hiatus and surround the urethra and anus, forming the sphincter musculatures.

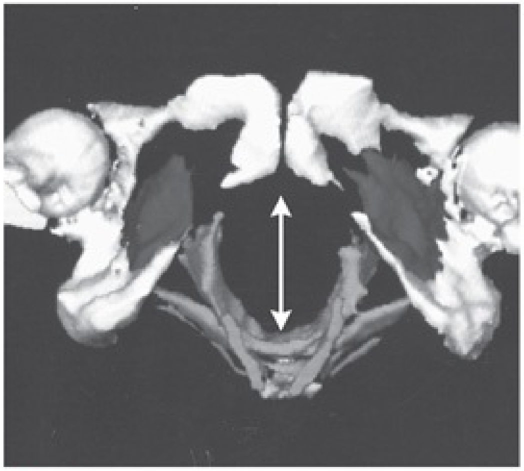

FIGURE 48.8 Three-dimensional MRI reconstruction of the levator musculature, bony pelvis, and obturator musculature in a patient with multiple deliveries. The levator hiatus is widened (*arrow*); this represents the distance between the rectal canal and the pubic bone, called the puborectal line.

Areas of Special Interest: Obturator Anatomy

Prior to the introduction of the transobturator tape, the obturator anatomy was rarely studied in the context of POP. With the dramatic increase in the number of procedures, both for continence and prolapse, performed in this area and the arising complications, it is important for all urologists to understand the anatomic landmarks. The adductor longus tendon is a major landmark for trocar passage and protects the patient from injury to the neurovascular bundle. Safe entry and exit zones exist when the patient is properly positioned and landmarks are obeyed. When a sling is placed using this technique, it is important to understand that the mesh sling is placed through the obturator internus muscle via passage of the trocar. Complications are possible as a result of this placement; these include difficulty ambulating and pain with contraction of the obturator internus muscle.

PATHOPHYSIOLOGY OF PELVIC ORGAN PROLAPSE

Although the exact etiology of pelvic prolapse has yet to be clearly defined, many risk factors have been proposed in the development of prolapse. These risk factors can be placed into four categories:

(a) *predisposing* factors: genetics, race, and gender; (b) *inciting* factors: pregnancy and delivery, surgery, myopathy, and neuropathy; (c) *promoting* factors: obesity, smoking, pulmonary disease, constipation, and recreational or occupational activities that cause chronic increases in intra-abdominal pressure; and (d) *decompensating* factors: aging, menopause, debilitation, and medications (13). Any of the risk factors can result in attenuation of the uterosacral–cardinal ligament complex or breaks along the endopelvic fascia. Furthermore, muscle atrophy of the levator ani and coccygeus can lead to a widened levator hiatus and a compromise in the excretory function of the bladder and rectum. The loss of uterine support causes the cervix to move anteriorly, and the uterus then begins to shift posteriorly such that the intra-abdominal pressure is then directed on the anterior surface of the uterus. The uterus becomes progressively more retroverted until the axis of the uterus is essentially vertical. This position allows uterine prolapse to occur (14).

DIAGNOSIS

Standard evaluation of the patient with uterine prolapse includes a comprehensive history and physical examination, focusing on urinary and defecatory symptoms, sexual function, reproductive status, and other pelvic pathology. Postvoid residual urine volume and urinalysis are obtained for all patients. Urodynamic evaluation is not routinely performed unless there is a history of stress or urgency incontinence, incomplete emptying, obstructive voiding complaints, or bothersome overactive bladder symptoms. It is important to recognize that stress incontinence may be masked by the prolapse, which can cause kinking of the urethra.

The pelvic examination begins with external genitalia inspection for atrophy, tissue quality, and integrity of the perineum. The uterus and cervix is assessed for size, mobility, and any abnormal gross pathology. The anterior, posterior, and apical vaginal walls are examined separately with the aid of a half speculum to assess the presence of cystocele or rectocele. In both the lithotomy position and standing, the patient needs to bear down or cough to fully elicit the degree of prolapse. The Pelvic Organ Prolapse Quantification System (POP-Q) is a commonly used staging system for describing vaginal prolapse (15). The screening neurologic examination should evaluate gross sensory and motor function of both lower extremities, and lumbosacral function. This can be quickly achieved by assessing pelvic floor muscle strength, anal sphincter resting tone, voluntary anal contraction, and perineal sensation.

Often, the viscera behind the prolapsed vaginal wall cannot be accurately diagnosed. This is especially true for posterior vaginal wall protrusion, which may represent an enterocele, a rectocele, or a sigmoidocele. A careful bimanual examination with two separate fingers simultaneously in the rectum and vagina can help distinguish rectocele from enterocele or sigmoidocele. When the patient strains, an enterocele or sigmoidocele will often fill the space between the two viscus, whereas a rectocele will result in no change in the plane.

Dynamic magnetic resonance imaging (MRI) is unrivaled in its ability to characterize pelvic soft tissue. No contrast is used as the bladder is distinct on T2-weighted images. Sagittal images are taken of the pelvis with the patient at rest and then bearing down (Fig. 48.9). Additional radiologic imaging such as defecogram may be indicated for evaluation of bowel dysfunction associated with posterior prolapse. MR defecography involves dynamic evaluation of the pelvic floor, providing both structural and functional information. Standardization of the testing and interpretation of defecography is not established, however, and therefore, it is not recommended for routine clinical use, although it can be helpful in “high” rectoceles when an enterocele is suspected (16).

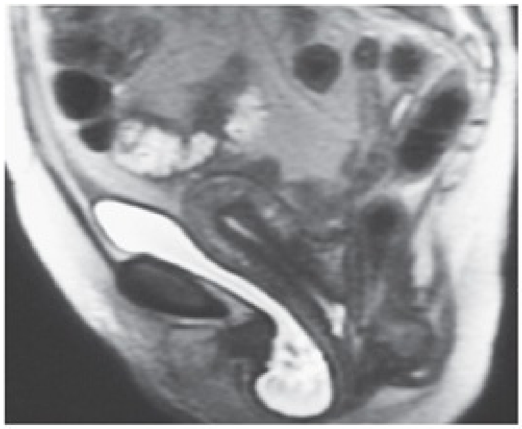

FIGURE 48.9 MRI of the pelvis. Dynamic MRI of the pelvis demonstrating uterine and bladder prolapse.

INDICATIONS FOR SURGERY

An individualized approach to patients with advanced POP should be undertaken after consideration of multiple factors. The surgeon must consider all site-specific defects present as well as the patient's urinary, bowel, and sexual function. Surgical intervention for POP is indicated in patients with urinary retention, obstructive voiding, hydronephrosis, difficult defection, chronic vaginal discharge, and/or ulceration as well as persistent pelvic pressure, dyspareunia, and sensation of the bulge. It is of paramount importance to determine the most bothersome symptoms for the patient and to highlight the patient's goals and expectations of treatment. Following this, the patient's general medical condition and other factors are considered when deciding on a management plan.

Isolated rectoceles usually do not need surgical repair due to the possibility of postoperative dyspareunia unless the patient is bothered by symptoms. Obstructive defecation, lower pelvic pressure, and symptomatic prolapse of the posterior wall are some of the indications for rectocele repair. Some suggest conservative management with pelvic floor rehabilitation or referral to colorectal surgery or occupational therapy for defecation disorders prior to surgical intervention.

ALTERNATIVE THERAPY

Asymptomatic or minimally bothered patients may opt for observation or pelvic floor muscle rehabilitation. For those symptomatic patients who are poor surgical candidates or prefer a nonsurgical approach, mechanical support with a pessary made of silicon or soft plastic can be used to reduce the POP. These patients undergo a pessary fitting in one or two office visits, followed by a teaching session with a nurse or physician. Women with symptomatic improvement are taught to place and remove the pessary at least twice weekly and prior to intercourse and should return every 6 to 12 months for an office evaluation and examination. Women who are unable to remove the pessary may leave it in continuously and return every 3 months for pessary care. Such patients may benefit from vaginal estrogen cream, unless contraindicated, to reduce the risk of erosion. If vaginal erosion develops, the pessary should be removed and vaginal estrogen cream applied until the erosion is healed. The pessary can then be replaced, although a reduction in pessary size or type is advisable. Pessaries generally are less effective in supporting the posterior vaginal wall than in apical and anterior vaginal wall prolapse.

SURGICAL TECHNIQUES

There are several options for surgical management of POP. Prolapse can be approached vaginally or abdominally depending on its degree, patient characteristics, affected compartments, and desired outcomes. Colpocleisis can be offered to older frail women or to patients who no longer desire preservation of coital function. Although anterior vaginal prolapse is the most common, most women who present with POP have a combination of pelvic floor support defects affecting multiple compartments (anterior, apical, and posterior). Therefore, the importance of a thorough evaluation and complete repair of the whole pelvic floor cannot be overemphasized. Subtotal segmental repairs which do not address concomitant compartment defects may allow subsequent postoperative exaggeration of preexisting defects due to functional and anatomic changes.

The need to augment support of the pelvic floor with grafts such as synthetic mesh or biologic fascia is debated. Many would argue that supporting the patient’s weakened intrinsic fascia using a graft can achieve a better anatomic result and a more durable response. However, patient reported outcomes measures have not consistently favored augmented repairs. As a result, individualized approaches and thorough counseling on the risks and benefits of graft augmentation is advocated.

Regardless of technique, three basic tenets must be obeyed in pelvic reconstruction: (a) restoration of normal vaginal depth, caliber, and axis; (b) prevention of further POP; and (c) restoration and maintenance of normal bladder, bowel, and sexual function (7). We will now describe the various techniques of POP repair categorized by apical, anterior, and posterior compartments.

SURGICAL TECHNIQUES FOR APICAL COMPARTMENT

There is growing recognition that adequate support for the vaginal apex is an essential component of a durable surgical repair for women with advanced prolapse (17,18). Restoration of apical support has several good options with relatively high success rates and can be performed transvaginally or abdominally. Several studies suggest that the transvaginal approach is used in 80% to 90% of cases (19–22); it is believed that abdominal approach is a better choice for younger and sexually active women because it maximizes functional vaginal length and axis.

Vaginal Hysterectomy with Vault Suspension

Hysterectomy is commonly performed in the treatment of POP and can be approached abdominally, vaginally, laparoscopically, or robotically. Vaginal hysterectomy is preferred over abdominal surgery in the setting of benign disease such as uterine prolapse due to shorter operative time, fewer postoperative complications, and a shorter hospital stay (23,24). Relative contraindications for vaginal hysterectomy include a large uterus in proportion to a narrow introitus, uterine or cervical cancer, ovarian pathology, significant endometriosis, and a history of pelvic inflammatory disease, which may result in extensive scarring in the pelvis, making dissection difficult. As a genitourinary surgeon, one should be familiar with the surgical principles and technique of vaginal hysterectomy, as it is a critical component of female pelvic reconstruction.

The pear-shaped uterus consists of the corpus and the cervix and lies in the medial axial position, anteverted with the vertical axis of the uterus perpendicular to the axis of the vagina. The corpus or body of the uterus is enclosed between the double-layered broad ligaments. The main uterine support is provided by the uterosacral and cardinal (Mackenrodt) ligaments. During hysterectomy, these ligaments must be carefully identified and controlled, as they will be incorporated into the vaginal cuff to successfully re-establish proper vault support. Complete correction of uterovaginal prolapse at the time of hysterectomy should include not only fixation of the vaginal apex to the uterosacral or cardinal ligaments but also reapproximation of the bladder and rectum to close the cul-de-sac.

Broad-spectrum prophylactic antibiotics are administered preoperatively. Compression stockings are placed prior to incision to prevent venous thromboembolic events and subcutaneous heparin administered based on patient risk stratification. Following successful induction of anesthesia, the patient is placed in the high lithotomy Trendelenburg position. Care should be taken to avoid hyperflexion of the hips, which can result in femoral neuropathy. An iodine-based solution is used to cleanse the skin from the suprapubic area to the posterior perineum. A ring retractor with skin hooks is used to maintain exposure. The bladder is drained with a urethral catheter. The cervix is grasped at the 12 and 6 o'clock positions using Lahey clamps. A circumferential incision is made at the cervicovaginal junction using electrocautery (Fig. 48.10). The vagina and bladder base is dissected off the cervix for several centimeters. The anterior cul-de-sac is carefully entered using sharp dissection (Fig. 48.11A). Gentle downward traction, visualization of the glistening surface of the uterus, and limiting the dissection to the midline of the uterus are used to help to minimize risk of cystotomy. Once the anterior cul-de-sac is entered, electrocautery is used to extend the incision laterally to allow placement of a Heaney retractor (Fig. 48.11B).

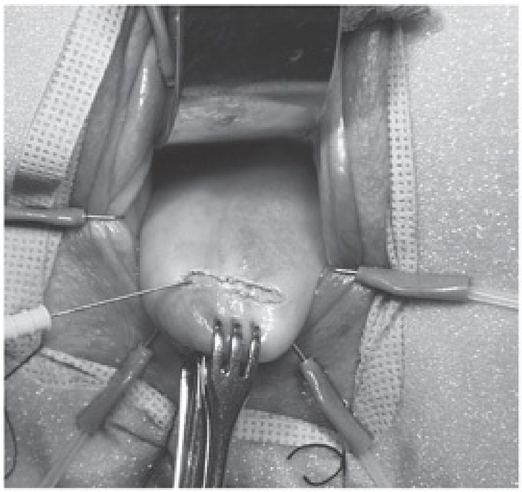

FIGURE 48.10 Incision. A circumferential incision is made approximately 1 cm from the cervical os with electrocautery.

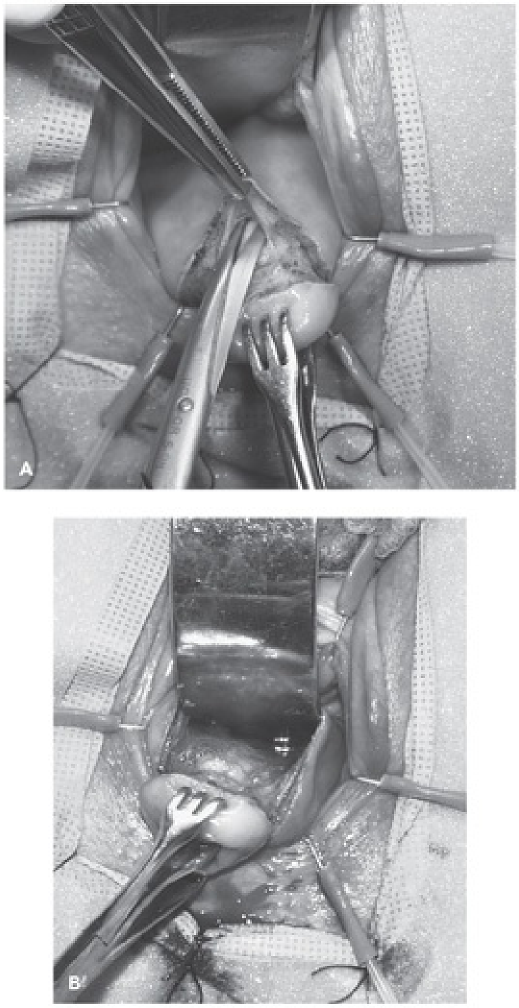

FIGURE 48.11 Exposure of the anterior uterus. Sharp dissection is used to (A) expose the anterior cul-de-sac and (B) place a Heaney retractor.

The posterior cul-de-sac is entered similarly, and the peritoneum is opened sharply using curved Mayo scissors (Fig. 48.12). Any adhesions encountered should be lysed with limited sharp dissection to allow placement of another Heaney retractor. If difficulty is encountered when attempting to enter the peritoneum, the hysterectomy can be initiated in an extraperitoneal fashion by severing the uterosacral ligament and caudal portions of the cardinal ligament close to the cervix. This maneuver mobilizes the uterus to provide better visualization.

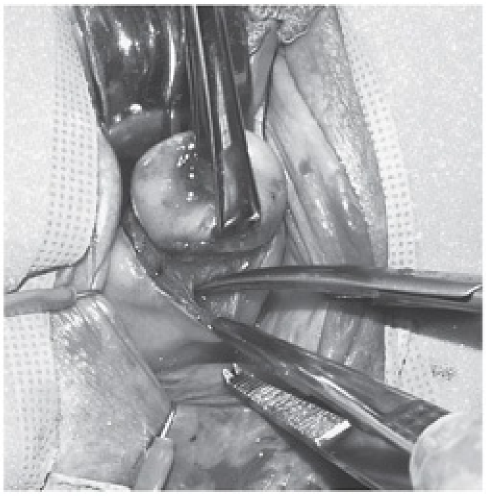

FIGURE 48.12 Exposure of posterior cul-de-sac and sharp entry into the peritoneum.

Next, the uterosacral and cardinal ligament complex is divided by placing the cervix on careful traction and passing a large right-angle clamp from the posterior cul-de-sac parallel to the cervix.

The right-angle clamp is used to expose the ligament, which is then grasped with a Phaneuf clamp and ligated with electrocautery (Fig. 48.13). The stumps are oversewn with figure-of-eight 0 Vicryl sutures. The ends of the sutures are clamped and secured on the ring retractor. Then the uterine pedicles are carefully identified, isolated, and divided in similar fashion (Fig. 48.14). After the contralateral ligament and pedicles are likewise controlled, the uterus can then be manually everted and brought outside the introitus (Fig. 48.15). Safe entry into the anterior peritoneum can be made by placing a finger anteriorly over the uterine fundus to elevate the peritoneum. Electrocautery can then be used to incise the peritoneum overlying the surgeon's finger. The broad ligaments are now ligated as previously discussed (Fig. 48.16). If an oophorectomy is not planned, the ovarian attachments are also now divided and the uterus is removed.

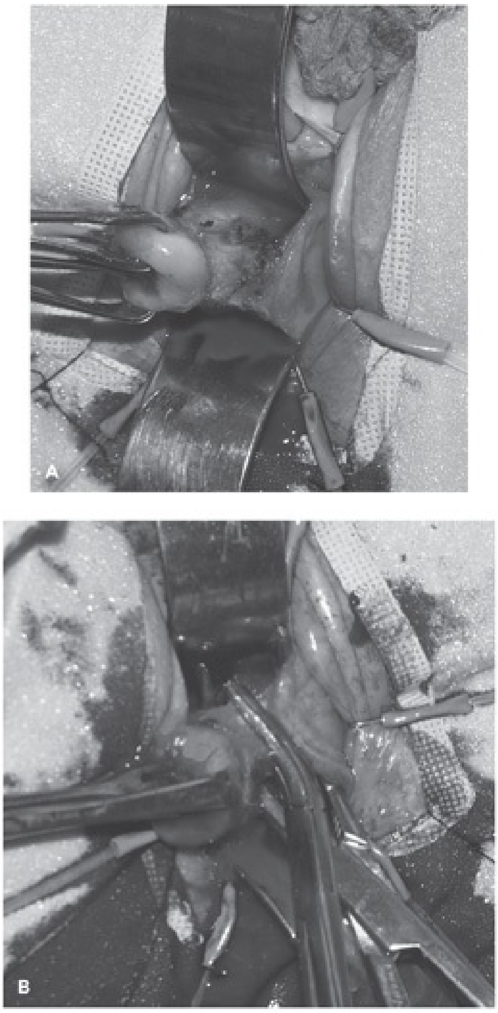

FIGURE 48.13 Isolation of cardinal–uterosacral ligaments. Right-angle and Phaneuf clamps are used in succession to (A) better delineate the cardinal–uterosacral complex before (B) transection.

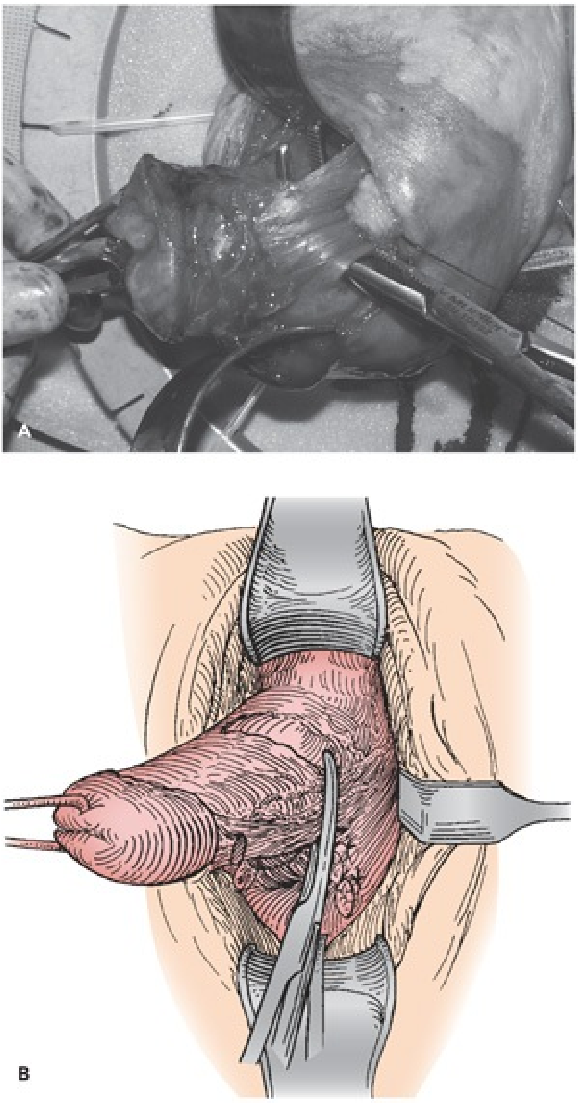

FIGURE 48.14 The uterine pedicles are carefully identified (**A**), isolated, and divided (**B**).

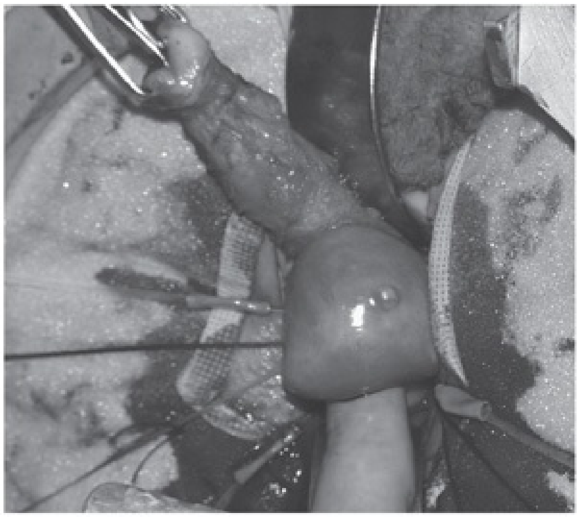

FIGURE 48.15 Eversion of the uterus. After the bilateral cardinal–uterosacral ligaments have been ligated, the uterus is manually everted.

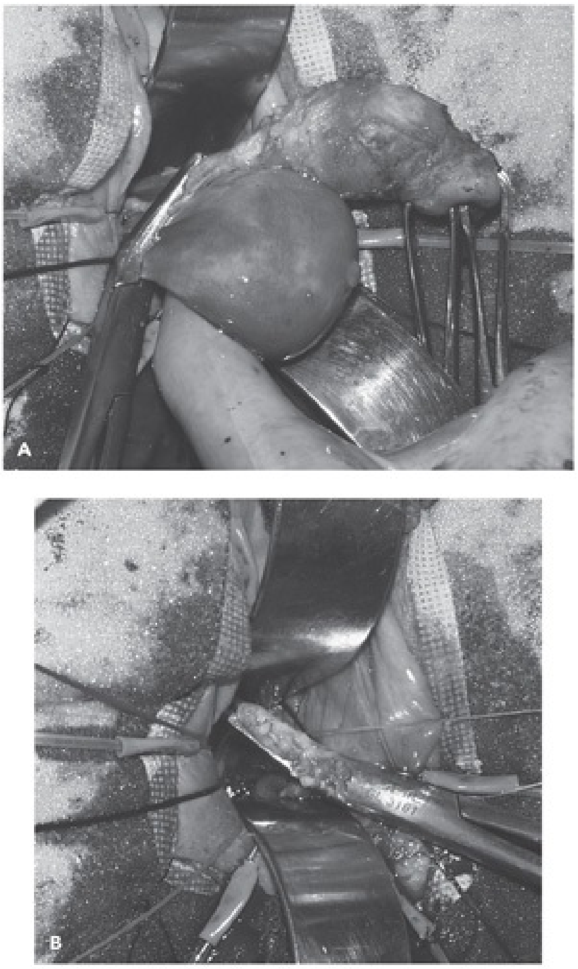

FIGURE 48.16 Division of the broad ligament. The surgeon's index finger is (**A**) inserted into the peritoneal cavity and hooked around the broad ligament, which is (**B**) then ligated in the same fashion as the cardinal–uterosacral ligaments.

After hysterectomy, the vault support and vaginal depth must be restored. This is accomplished by obliterating the cul-de-sac to prevent enterocele recurrence and by sacrospinous or uterosacral ligament fixation of the vaginal apex.

Two Betadine-soaked laparotomy pads are placed intraperitoneally to pack away the peritoneal contents. Next, the coccygeus–sacrospinous ligament complex is identified by palpating the ischial spine and tracing the taut triangular band of fascia medially and posteriorly as it attaches to the edges of the sacrum. Next, we use two Allis clamps to grasp the area of the future vaginal cuff and apply downward traction toward the coccygeus–sacrospinous ligament complex to determine the extent of the apical prolapse and associated pelvic support defects. If concomitant cystocele still exists after reducing the apical prolapse, we will perform a formal cystocele repair. The technique of bilateral sacrospinous ligament fixation is challenging due to the difficulty in maintaining good visualization in the deep pelvis through the vagina and the risk of injuring the pudendal vessels, the lumbosacral plexus, and the ureters, which are in close proximity. To optimize this exposure, three retractors are employed: (a) A long-handled Breisky is placed anteriorly to retract the peritoneal contents from descending; (b) another Breisky or Heaney is used to displace the rectum laterally; and (c) a Heaney retractor is then carefully placed posteriorly just distal to the tight cordlike coccygeus–sacrospinous ligament complex. We begin by placing a 1-0 Vicryl suture brought from outside the vaginal wall into the peritoneal cavity (in the area of the ligated uterosacral–cardinal ligament complex). Instruments are switched to a long-handled needle driver and long gastroplasty forceps to place that same suture in figure-of-eight fashion in the coccygeus–sacrospinous ligament complex on the corresponding side. The direction of the needle must be horizontal, since one can easily damage the nearby neurovascular structures and ureters. It helps to carefully palpate and identify the tight cordlike sacrospinous ligament structure in the substance of the coccygeus prior to suture placement. The same suture is then exited through the vaginal wall just above the area of the uterosacral–cardinal ligament complex and tagged separately. A second 1 Vicryl suture is placed on the contralateral side in the exact same fashion.

Two purse-string sutures of 0 Vicryl are now placed to close the cul-de-sac. These sutures incorporate the prerectal fascia, the uterosacral–cardinal ligament complex, the broad ligaments, and the perivesical fascia (Fig. 48.17). It is important to stay in the midline when incorporating the perivesical fascia to avoid ureteral injury. The purse-string sutures are tagged at this time. The sutures of the previously ligated pedicles of the broad ligaments and the uterosacral–cardinal ligament complex are identified on each side and tied in the midline. The purse-string culdoplasty sutures are now cinched and tied. If simultaneous repair of other prolapse is planned, it is now performed. The sacrospinous ligament vault suspension sutures are tied last after any cystocele repair and vaginal cuff closure. It is important to push down the vault to the sacrum while tying down the vault suspension sutures to achieve optimal vaginal depth.

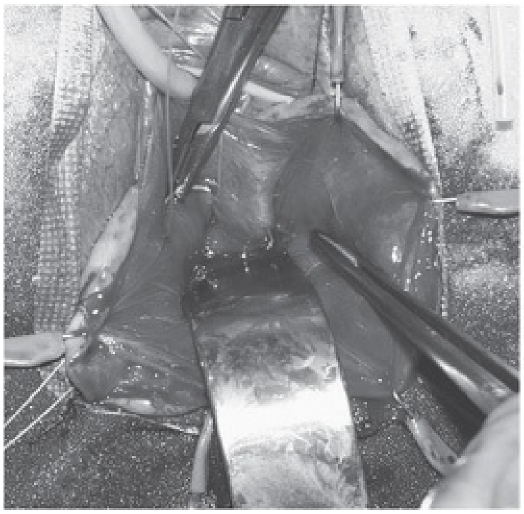

FIGURE 48.17 Placement of purse-string culdoplasty sutures. Inside the peritoneal cavity, two 1 Vicryl purse-string sutures are placed to obliterate the cul-de-sacs and approximate the prevesical and prerectal fascia.

Cystoscopy is performed routinely after giving indigo carmine to assess for a healthy jet stream of urine from the ureteric orifices. If there is any question of ureteric injury, gentle passage of a ureteral catheter or retrograde pyelography may be performed. If obstruction is encountered, the repair is taken down systematically starting with the vault suspension sutures.

Transvaginal Enterocele Repair

Posthysterectomy vault prolapse usually has an enterocele component that will be corrected first. The surgeon may choose to open the enterocele sac for an intraperitoneal repair or elect an extraperitoneal repair. Placement of vault suspension sutures can be daunting regardless of the chosen approach. It is important to understand where it is safe and where it is dangerous to place sutures. Sutures can be safely placed in the uterosacral ligament, the sacrospinous ligament, or the anterior longitudinal fascia of the sacral promontory. For vaginal ligament suspension, the needle should be directed downward rather than laterally or superiorly where other important structures lie (see Fig. 48.5). It is imperative to avoid going cephalad to the sacrospinous ligament, as the lumbosacral plexus can be injured or trapped with a suture. The ureter can be damaged, as can the pudendal nerve, if the needle is placed laterally at the time of uterosacral or sacrospinous fixation.

The patient is placed in the dorsal lithotomy position and prepped appropriately. A Scott ring retractor (Lone Star Medical Corp) is commonly used to aid with exposure; some authors also advocate for the use of rectal packing. The bladder is drained with a urethral catheter. The prolapsed vaginal wall is infiltrated with normal saline or lidocaine-epinephrine solution for hydrodissection, and incision is made along the length of the enterocele (Fig. 48.18). The vaginal wall is carefully dissected away from the peritoneal sac. Dissection in the proper avascular plane is performed with blunt dissection using a sponge and sharp dissection in the areas where sac is densely adherent to the vaginal epithelium. Dissection proceeds until the neck of the sac is reached (Fig. 48.19). The enterocele sac is opened at this point. Next, we proceed with the retraction of the peritoneal contents in order to place sutures for the enterocele sac closure. Retraction is best achieved using pediatric lap pads and a Haney or a narrow Deaver retractor (Fig. 48.20). Closure of the sac is performed with a 0 or 1 polyglycolic acid (PGA) suture.

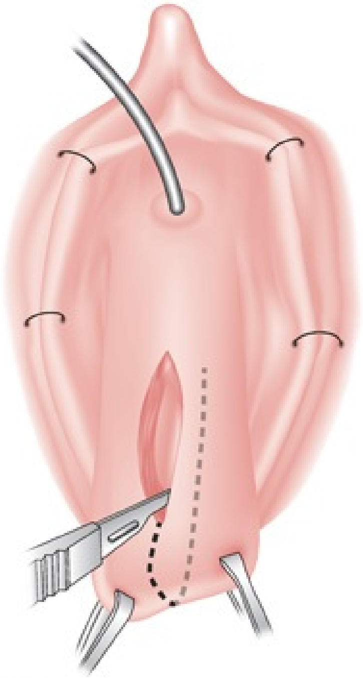

FIGURE 48.18 The vaginal wall is grasped with two Allis clamps and brought outside the vaginal introitus. A midline incision is made and opened on the dotted line.

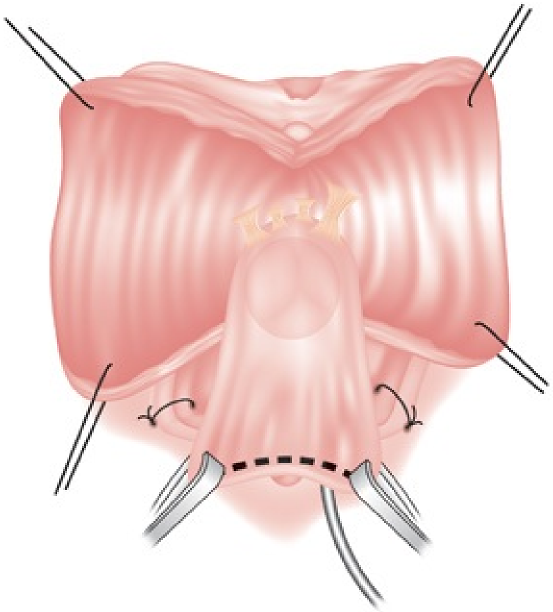

FIGURE 48.19 Enterocele sac completely dissected to its neck and opened on the dotted line.

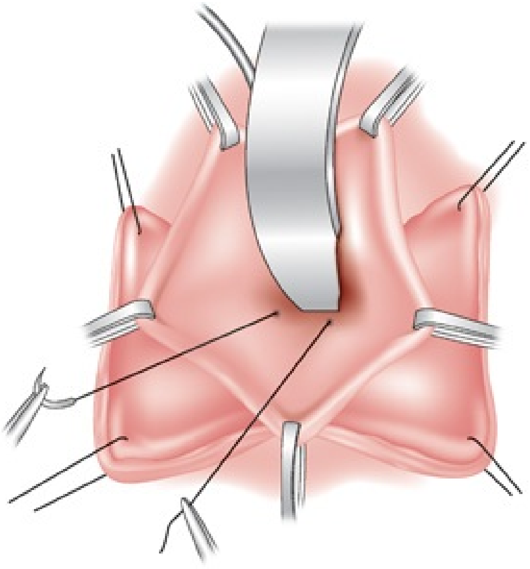

FIGURE 48.20 A Deaver retractor is used to retract abdominal contents so that purse-string sutures can be placed.

The enterocele repair begins posteriorly, whereas the abdominal contents are retracted anteriorly. The suture is first placed through the peritoneum and into the prerectal fascia that overlies the rectum (see Fig. 48.20). A circumferential closure of the defect is then performed by placing the purse-string suture laterally in the right uterosacral–cardinal ligament complex, anteriorly in the peritoneum overlying the base of the bladder, laterally on the left in the uterosacral–cardinal ligament complex, and finally again posteriorly in the prerectal fascia (Fig. 48.21). A second suture can be placed in close proximity to the first suture incorporating the same components. When no vault suspension is planned, the uterosacral–cardinal ligament complex needs to be incorporated into the repair to support the vaginal apex. The depth of the suture placement is an important determinant of the postoperative depth of the vaginal vault and needs to be carefully planned. Cystoscopy is performed to confirm no injury to the bladder and to observe ureteral jets after previously administered indigo carmine.

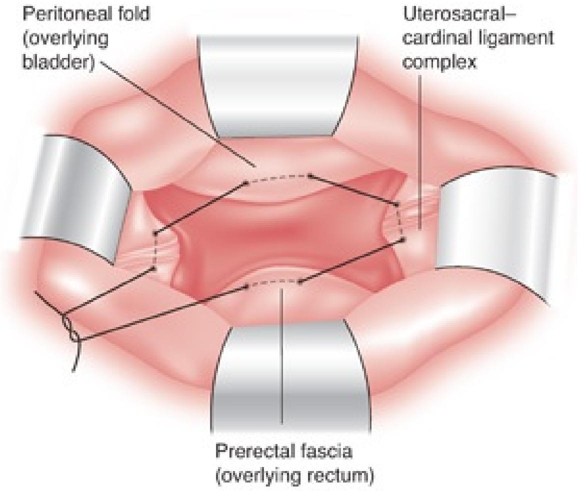
Peritoneal fold (overlying bladder)
Uterosacral–cardinal ligament complex
Prerectal fascia (overlying rectum)

FIGURE 48.21 Placement of purse-string sutures.

Several approaches for apical vault suspension are available and chosen based on patient's anatomy and surgeon's training and expertise. Most commonly performed are the McCall culdoplasty, the uterosacral ligament suspension, and the sacrospinous ligament fixation.

McCall Culdoplasty

McCall (25) first described a technique that used the uterosacral ligaments for support and correction of enterocele in 1957. Despite several modifications, the basic principles remain the same. The internal “McCall sutures” are passed through the uterosacral ligament; most proximal being placed 2 cm above its cut edge. After stitching the uterosacral ligament, several bites of posterior peritoneum are taken in 1 to 2 cm intervals until the contralateral uterosacral ligament is reached. The suture is not tied, and additional sutures are placed in a similar fashion as needed (Fig. 48.22). Next, the external McCall sutures are placed just lateral to the midline, through the proximal posterior vaginal wall and peritoneum. Similar to the internal McCall sutures, successive passes are made through the posterior peritoneum until the contralateral uterosacral ligament is reached. The internal sutures are each tied, followed by the external sutures, which suspend the vaginal wall at the level of the uterosacral ligaments.

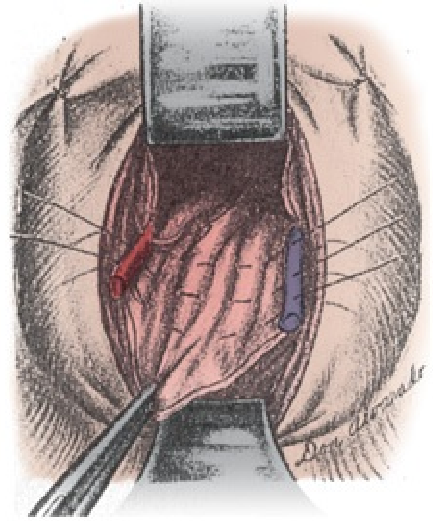

FIGURE 48.22 Placement of internal McCall sutures. (Reprinted with permission from McCall ML. Posterior culdoplasty: surgical correction of enterocele during vaginal hysterectomy: a preliminary report. *Am J Obstet Gynecol* 1957;10:595–602. Copyright © 1957 Elsevier.)

Uterosacral Ligament Fixation

Suspension of the vaginal vault to the uterosacral ligaments, as described by Shull et al. (26), provides a more natural vaginal axis than the sacrospinous ligament fixation. A vertical midline incision is made in the vaginal epithelium. The vaginal wall is then carefully dissected away from the enterocele sac, and the sac is opened to pack the bowel away as described earlier. It is useful to place a marking suture at 3 and 9 o’clock position at the vaginal apex (prior site of the uterosacral ligament attachment). As Shull et al. (26) originally described (Fig. 48.23), the remnants of the uterosacral ligaments are identified posterior and medial to the ischial spines at approximately the 4 and 8 o’clock positions. An Allis clamp can be used to apply traction to the tissue and the uterosacral ligament can be palpated toward the sacrum.

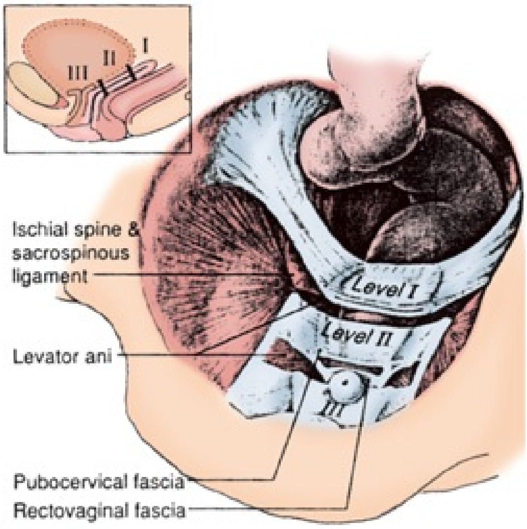

FIGURE 48.23 Level I (suspension) and level II (attachment). In level I, the paracolpium suspends the vagina from the lateral pelvic walls. Fibers of level I extend both vertically and also posteriorly toward the sacrum. In level II, the vagina is attached to the ATFP and superior fascia of levator ani. (Reprinted with permission from DeLancey JOL. Anatomic aspects of vaginal eversion after hysterectomy. *Am J Obstet Gynecol.* 1992;166:1717–1728. Copyright © 1992 Mosby. Published by Mosby, Inc. All rights reserved.)

Two or three delayed absorbable or permanent double-armed sutures are placed through the uterosacral ligaments on each side. First suture is placed at the level of the ischial spine. Subsequent sutures are placed proximal to the last. Sutures should be passed lateral-to-medial to avoid ureteral injury. The double-armed sutures are placed through the pubocervical and rectovaginal fascia (Figs. 48.24 and 48.25) (26). The most proximal sutures are sewn to the most medial aspect of the pubocervical and rectovaginal fascia. More distal sutures are placed more laterally (see Fig. 48.24). An anterior colporrhaphy may be done at this point if necessary. Intravenous indigo carmine is administered. The vaginal epithelium is then closed and the suspension sutures are tied but left long and tagged. Cystoscopy is performed. Once the ureteral patency is confirmed, sutures are trimmed.

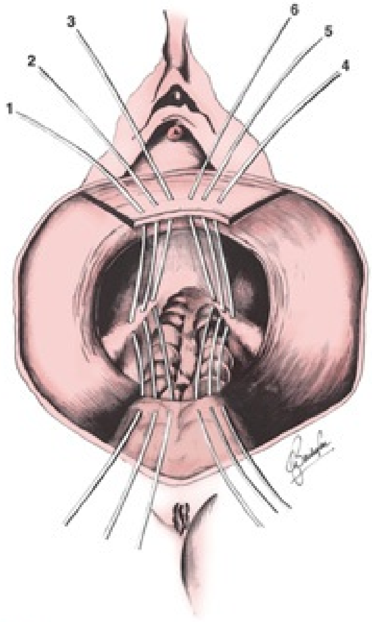

FIGURE 48.24 Sutures are placed in uterosacral ligaments bilaterally. One arm of each suture is placed in the pubocervical fascia and the other in the rectovaginal fascia. (Reprinted with permission from Shull BL, Bachofen C, Coates KW, et al. A transvaginal approach to repair of apical and other associated sites of pelvic organ prolapse with uterosacral ligaments. *Am J Obstet Gynecol* 2000;183:1365–1373. Copyright © 2000 Mosby, Inc. All rights reserved.)

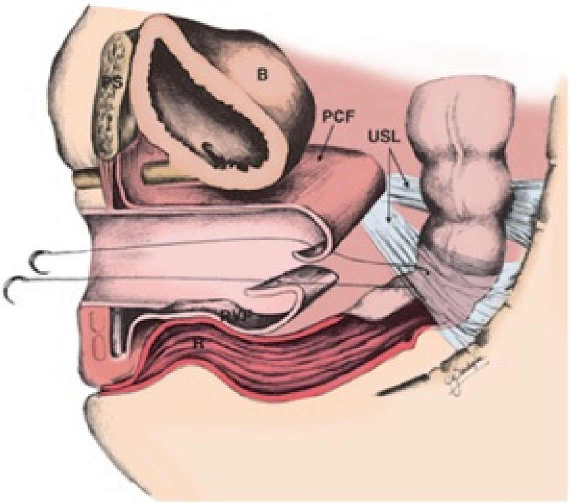

FIGURE 48.25 Sagittal view of suspensory suture in uterosacral ligament (*USL*), pubocervical fascia (*PCF*), and rectovaginal fascia (*RVF*). *B*, bladder; *PS*, pubic symphysis; *R*, rectum. (Reprinted with permission from Shull BL, Bachofen C, Coates KW, et al. A transvaginal approach to repair of apical and other associated sites of pelvic organ prolapse with uterosacral ligaments. *Am J Obstet Gynecol* 2000;183:1365–1373. Copyright © 2000 Mosby, Inc. All rights reserved.)

Sacrospinous Ligament Fixation

Sacrospinous ligament fixation was introduced in Germany by Amreich and Richter (27) in 1951 and made popular in the United States by Randal and Nichols (28). This approach fixes apex unilaterally or bilaterally to the sacrospinous ligament. The sacrospinous ligament stretches from the ischial spine to the sacrum and is covered by the coccygeus muscle. The posterior vaginal wall is incised in the midline and dissected laterally. The sacrospinous ligament is identified and reached. This is achieved by penetrating the rectal pillar (pararectal fascia) near the ischial spine using blunt and sharp dissection. Blunt dissection of the pararectal space can be performed with a combination of finger dissection and the use of deep Breisky-Navratil retractors. The rectum is retracted medially, and bladder anteriorly. (Fig. 48.26).

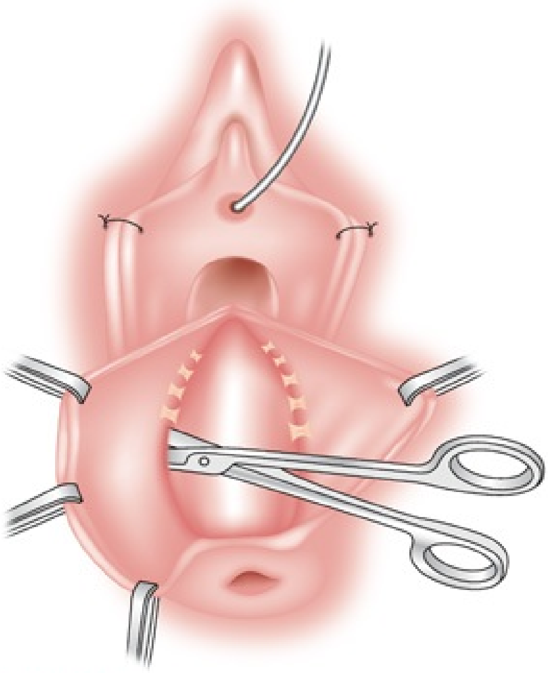

FIGURE 48.26 Dissection for SSLF. The rectal pillars are sharply penetrated and the pararectal space is entered. The space is widened with blunt dissection to expose the superior surface of the pelvic diaphragm. The sacrospinous ligament can then be palpated and the coccygeus muscle overlying it can be seen.

This dissection is performed until the sacrospinous ligament is palpated and the overlying coccygeus muscle is seen. We carefully dissect over the ligament using a spreading motion of the Metzenbaum scissors. This is done to ensure that a strong portion of the ligament under the coccygeus muscle is incorporated as the suture is placed. A permanent 1-0 braided suture is placed into the well-identified and dissected ligament–muscle complex 2 cm medial to the ischial spine. It is important to place the suture in this position to avoid injury to the pudendal nerve and vessels, which run posterior to the ischial spine as they enter Alcock canal. Visualization of the ligament itself helps avoid incorrect placement of the sutures. Several devices have been developed to aid with the suture placement into the ligament, including the Deschamps ligature carrier, nondisposable Miya hook (29), and a disposable Capio transvaginal suture-capturing device (Boston Scientific). These instruments aid with the suture placement and retrieval in this deep and narrow space. Tension should be placed on the suture to ensure its strong placement in the ligament. A second suture should be placed adjacent to the first. Each of these sutures is then placed through the vaginal wall, excluding the epithelial layer at the level of the apex, approximately 1 cm apart, and left untied. If a rectocele is present, it is repaired at this time. The apex of the vagina can be directed under finger guidance to the deepest possible portion, where it will be fixed. The vaginal wall is then closed with a running interlocking 2-0 PGA suture, and then the previously placed sacrospinous ligament fixation sutures are individually tied. Modifications of anterior approach (30) and bilateral fixation have been developed to potentially reduce anterior compartment recurrence.

Augmentation of the apical prolapse repair with synthetic material became increasingly popular in the early 2000s. It was motivated in part by the presumed reduction in the incidence of anatomical recurrence following the primary repair. Complications related to the use of synthetic mesh such as dyspareunia, mesh extrusion, and erosion led to the release of several statements by the U.S. Food and Drug Administration (FDA) (31). In addition, a widespread publicity campaign targeted women with previously placed vaginal mesh for POP as well as instances of litigation have resulted in fear and confusion among patients as well as providers. Minimally invasive abdominal approaches rapidly developed within the same timeframe and currently are favored by many providers. As a result, mesh augmented transvaginal repair is reserved for a minority of carefully selected cases. Nonetheless, even with transabdominally placed mesh, long-term follow-up suggests a >10% risk of vaginal mesh exposure (32).

Open Sacral Colpopexy

A transabdominal approach to apical repair can be performed by open, robotic-assisted laparoscopic and pure laparoscopic approaches. The principles of the operation remain the same regardless of approach, with the critical elements as follows:

- Permanent mesh (type I macroporous, monofilament) as graft material
- Secure suture fixation of the graft to the sacral promontory and vaginal cuff
- Complete enterocele reduction and culdoplasty
- Anti-incontinence procedure as indicated

The patient is placed in low lithotomy position to allow both transvaginal and transabdominal access. Typically, a Pfannenstiel incision is preferred by patients although visualization of the sacral promontory may be slightly more difficult. If one anticipates suboptimal exposure due to patient’s body habitus or prior surgical history (especially if prior mesh repair was performed), a low midline abdominal incision should be used. The following is a description of the operative technique of abdominal sacral colpopexy (ASC) and abdominal enterocele repair.

Once the incision is made and the peritoneal cavity entered, lysis of adhesions is performed as necessary and bowel is packed out of the pelvis above the level of the sacral promontory to achieve optimal exposure. Next, an incision is made in the posterior peritoneum over the sacral promontory, extending inferiorly along the right lateral aspect of the rectum (Fig. 48.27). Care is taken during fatty tissue dissection on the anterior surface of sacral promontory to avoid the middle sacral vein and presacral veins which can cause significant bleeding. Next, the peritoneum over the vaginal cuff is excised, and the peritoneum is dissected off the cuff of the vagina (Fig. 48.28).

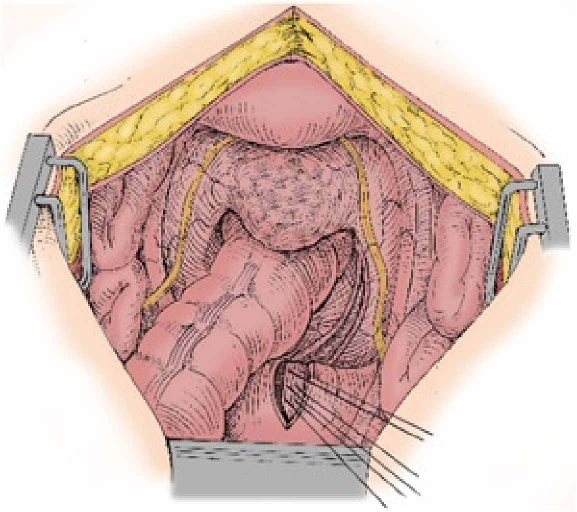

FIGURE 48.27 Incision of posterior peritoneum extending into pelvis lateral to rectum. Note secure suture placement into the sacral promontory.

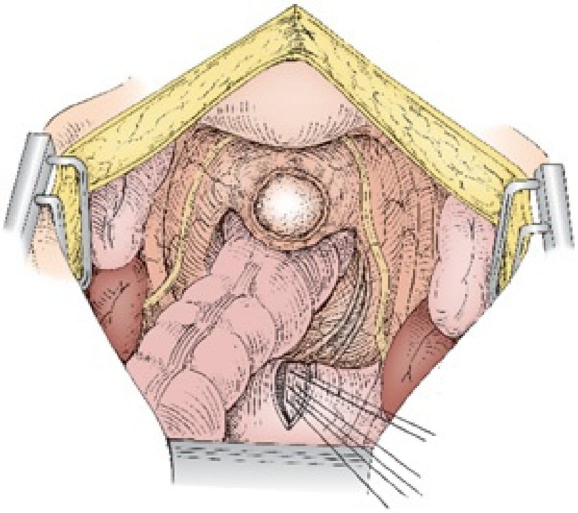

FIGURE 48.28 Peritoneum over vaginal cuff incised. Note: Dissection is made easier by use of EEA sizer.

The graft is secured to the vagina by folding over the cuff of the vagina and allowing the long end of the graft to exit posteriorly and extend to the sacrum. After placing an obturator in the vagina (large end-to-end anastomosis sizers are useful), the enterocele sac is identified and secured with an Allis clamp. If the enterocele is large, several purse-string sutures or linear 2-0 Ethibond sutures are placed into the enterocele sac to obliterate it (Fig. 48.29). This will reduce the cul-de-sac and facilitate the culdoplasty.

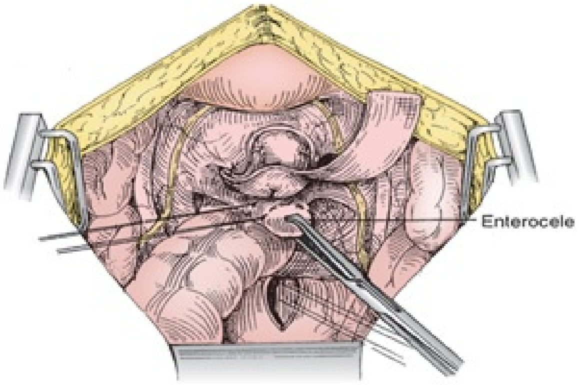

FIGURE 48.29 Isolation of enterocele from above. If enterocele is large, it may be reduced by plicating with purse-string sutures prior to cul-de-sac closure.

A Halban culdoplasty is performed by placing linear sutures (2-0 Ethibond) through the posterior peritoneum and on the outer surface of rectum up to the vaginal cuff (Fig. 48.30). The central sutures are placed through the obliterated enterocele sac to prevent recurrence of enterocele. Upward retraction of the graft will assist in exposing the cul-de-sac. Usually four to six sutures are used to complete adequate cul-de-sac closure.

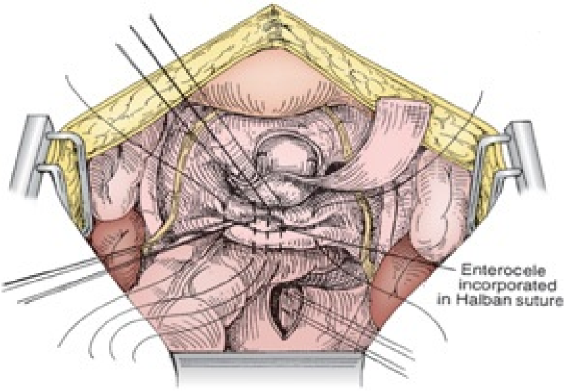

FIGURE 48.30 Halban culdoplasty. Longitudinal sutures placed to close cul-de-sac.

Next, the graft is secured to the promontory using 2-0 Ethibond sutures. Care must be taken to avoid excessive tension. Placing the obturator all the way into the vagina but not pushing the vagina upward establishes the proper length of the graft. The graft is placed around the right lateral aspect of the rectum. A space of two fingerbreadths between the graft and the rectum prevents compression of the rectum over the graft (Fig. 48.31). The excessive length of the graft is trimmed after fixation to the sacrum.

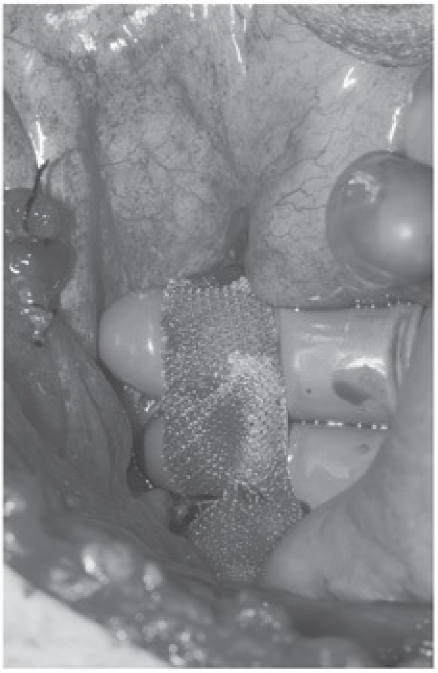

FIGURE 48.31 Intraoperative view: graft in final position. Note minimal tension placed on graft material. Incised peritoneum will be closed over graft after securing graft.

The graft is positioned in the retroperitoneal space by closing the presacral peritoneum over the graft and covering the graft on the vagina with the superior edge of the peritoneum over the vagina (Fig. 48.32). Stress incontinence procedures (if indicated) are then performed. The patient is then examined to determine if any ancillary prolapse repairs are needed.

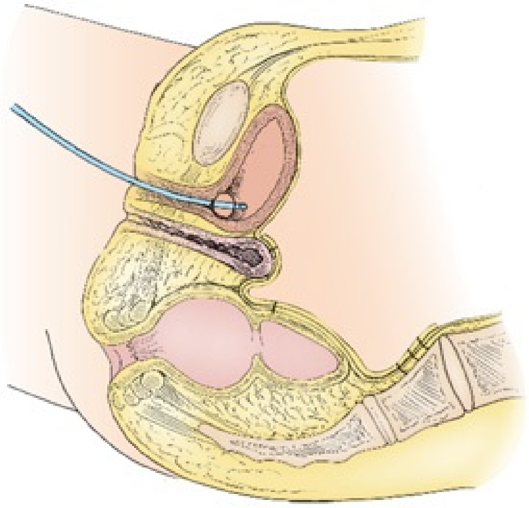

FIGURE 48.32 Final result. Graft positioned below posterior peritoneum by closing the previously incised peritoneum over the mesh.

Laparoscopic Sacral Colpopexy

Laparoscopic sacral colpopexy is very similar to the open technique. Peritoneal entry is achieved using Veress needle followed by CO_2 insufflation to pressure of 15 mm Hg. Five total laparoscopic ports are placed in the lower abdomen. Then lysis of adhesions, vaginal cuff dissection, and sacral promontory dissection are performed in sequence. After the vaginal cuff and sacral promontory are exposed, a 4 cm × 15 cm Y-shaped graft is constructed using monofilament nonabsorbable mesh. The two short arms of the Y-shaped mesh are sutured to the exposed vaginal cuff anteriorly and posteriorly using six sutures of 2-0 Ethibond (Fig. 48.33). Alternatively, absorbable sutures, such as

Vicryl or polydioxanone, may be used. Next, the long arm of the Y-shaped mesh is anchored to the sacral promontory in tension free fashion. The posterior peritoneum is closed over the entire length of the mesh to avoid any contact with the abdominal contents. Cystoscopy is routinely performed to ensure that there is no injury to the ureters and that there is no foreign suture or mesh material in the bladder.

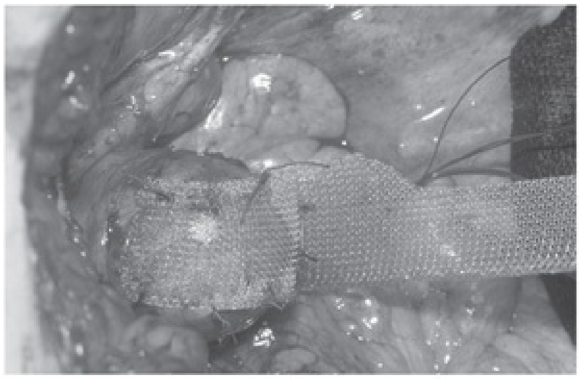

FIGURE 48.33 Intraoperative view: permanent graft secured to vaginal apex.

Robot-Assisted Laparoscopic Sacral Colpopexy

This technique is almost identical to the laparoscopic approach except the da Vinci robot is used to control the laparoscopic instruments designed for the da Vinci robot. It is believed that the sophisticated EndoWrist technology of the da Vinci robot allows for much faster intracorporeal suturing, less steep learning curve, and minimizes surgeon fatigue. However, these advantages must be weighed against the costly nature of da Vinci robot. Two studies evaluated the relative inpatient cost of ASC, laparoscopic sacral colpopexy (LSC), and robotic sacral colpopexy (RSC) and both concluded that ASC was the least costly inpatient option (33,34). Both models did not consider the potential benefits of minimally invasive approach and quicker recovery and return to work.

SURGICAL TECHNIQUES FOR ANTERIOR COMPARTMENT

Anterior prolapse can present as an isolated defect or as it frequently presents, in combination with the prolapse of the apex. Corrective techniques for the anterior defects can be used to repair the isolated defect or used in combination with apical procedures. These procedures can be performed using native tissues alone or augmented with either synthetic or biologic materials. Various commercial kits made of these synthetic and biologic grafts have been manufactured to improve the outcomes of anterior compartment prolapse repair. Detailed review of all the proprietary kits is beyond the scope of this chapter. One should note, however, that these devices apply similar anatomic principles as the procedures described in the following section and that a solid understanding of pelvic floor anatomy is paramount to successful restoration of POP. Furthermore, there is ongoing investigation by the FDA on the safety of transvaginal mesh devices and all comparative data on prolapse surgery outcomes should be interpreted with caution (31).

Anterior Colporrhaphy

After appropriate patient positioning and Foley catheter placement, the anterior vaginal wall is infiltrated with normal saline or lidocaine-epinephrine solution to facilitate hydrodissection. A midline incision extending from the bladder neck to the level of the vaginal cuff or to just above the cervix is made. Vaginal wall is dissected from the underlying pubocervical fascia. Countertraction by the index finger of the nondominant hand and traction on the Allis clamp helps to facilitate the dissection. The dissection continues laterally to the ischiopubic rami, apically to the level of the cuff and distally to the bladder neck (Fig. 48.34). The pubocervical fascia is plicated using a series of interrupted sutures across the midline. 2-0 PGA suture is commonly used. The cardinal ligaments first brought together in the most proximal aspect of the repair. Plication sutures are placed starting proximally and in 1-cm intervals toward the bladder neck. Sutures are tied after all the sutures have been placed. If a concomitant apical repair is performed, the apical plication sutures can be attached to the suspension sutures for additional support. If a synthetic midurethral sling procedure is planned as well, it is performed through a separate distal anterior vaginal incision. Cystoscopy is performed to ensure that the bladder is intact and ureteral efflux is present. Vaginal closure is then carried out using a running 2-0 absorbable suture.

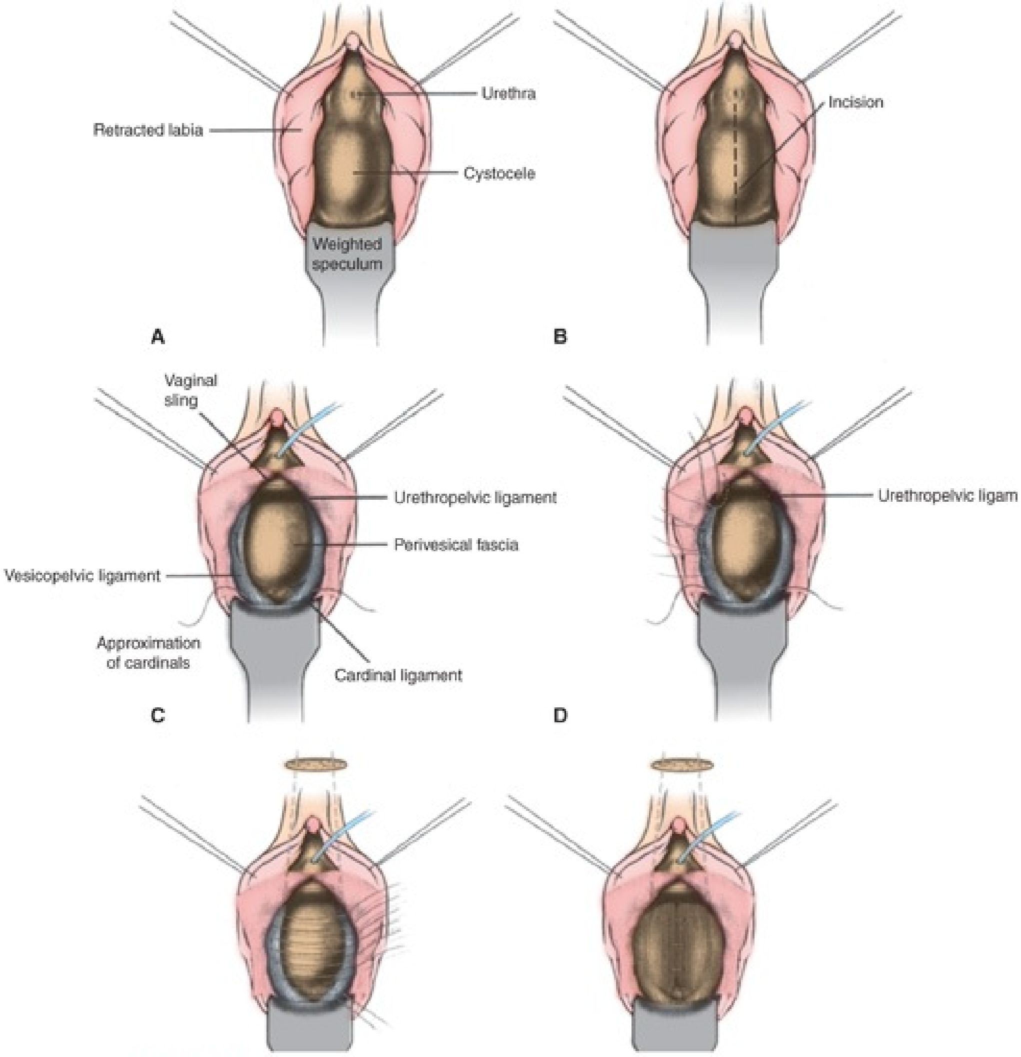

FIGURE 48.34 A: Demonstration of the central cystocele defect with preservation of the lateral vaginal sulci. B: A midline incision is created from the midurethra to vaginal apex in the vaginal wall. The retropubic space is developed on either side of the urethra and bladder. C: The vesicopelvic ligaments are identified, as are the cardinal ligaments. The cardinal ligament complex is reconstituted in the midline with sutures so as to provide apical support for the repair. D: For those repairs involving suture suspension techniques, sutures may be placed throughout the vesical pelvic ligament and transposed from the vaginal to suprapubic area for subsequent stabilization. These steps are repeated on the contralateral side. E: In those circumstances where plication alone is performed, sutures are placed across the base of the bladder from the vesicopelvic ligament on one side to the vesicopelvic ligament on the contralateral side and the two structures are reapproximated. F: Completion of combined plication repair with needle suspension of the proximal urethra and bladder neck.

Vaginal Paravaginal Repair

The paravaginal procedure performed through a vaginal incision exploits the ATFP as an anchoring point for sutures placed through the anterior vaginal wall on either side of the bladder base. The surgical field is prepared as discussed previously with dissection of the retropubic space, which frees up the base of the bladder from the pelvic floor. The dissection is extended laterally to the pubic ramus. Using blunt dissection, weak and attenuated attachments from bladder neck to the ischial spine are taken down. Once the dissection is complete, the bladder base is retracted medially with curved retractors to identify ATFP and/or obturator fascia. A 1-0 permanent suture is placed into the white line of the ATFP just distal to the ischial spine. A series of four to six 1-0 sutures are then placed in sequence toward the urethrovesical junction. These sutures are then passed through the pubocervical fascia. A small amount of lateral vaginal wall can also be incorporated. These steps are repeated on the contralateral side. The sutures are then tied distal to proximal and the cystocele is reduced. Cystoscopy is performed to ensure that the bladder is intact and ureteral efflux is present. Vaginal closure is then carried out using a running 2-0 absorbable suture.

SURGICAL TECHNIQUES FOR POSTERIOR COMPARTMENT

Although rectocele repair has been practiced for >100 years, the most effective surgical treatment remains undetermined. The three surgical routes described in the literature for repair of posterior wall prolapse are transvaginal, transanal, and abdominal. Among the different surgical routes, the transvaginal approach is the most commonly practiced approach. The transanal route was thought to be indicated for cases of small distal rectocele and is generally done by colorectal surgeons. Today, this is less commonly practiced because of the possible impairment of the anal sphincter as a result of its dilatation during the surgery. The abdominal approach is reserved for rare instances when there is associated rectal prolapse or advanced apical prolapse.

Although graft-augmented posterior repairs have been performed, they have fallen in popularity due to recent FDA warnings on the use of transvaginal mesh. Furthermore, several studies have shown little benefit to augmenting native tissue repair with biologic or synthetic mesh (35–37). We will therefore focus our discussion on commonly performed transvaginal techniques: posterior colporrhaphy, site-specific repair, and perineal reconstruction.

Posterior Colporrhaphy

Posterior colporrhaphy, also known as “traditional repair” is a transvaginal midline plication procedure commonly performed by general gynecologists and urologists. Prior to all pelvic reconstructive procedures involving the posterior compartment, bowel prep is recommended. Preoperative antibiotic with coverage of gram-negative organisms is given at the start of the procedure. Following the administration of general or spinal anesthesia, the patient is positioned in the high lithotomy position with care to ensure the neural safety of all four extremities. She is prepped and draped in a sterile fashion, and a Foley catheter is inserted. Exam under anesthesia is performed to reassess all compartments and ensure that the surgical procedures chosen are adequate (Fig. 48.35). A self-retaining vaginal wall retractor such as the Lone Star (Lone Star Medical Products) is placed. Some surgeons inject plain saline or epinephrine/saline solution diluted to 1/200,000 into the submucosal tissue to aid in the dissection and help with hemostasis.

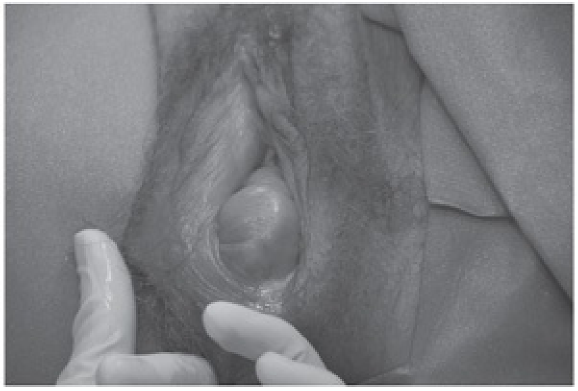

FIGURE 48.35 Rectal examination of a woman with a rectocele. The vaginal apex is 6 cm proximal to the hymen but the posterior vaginal wall distal edge protrudes past the introitus when standing. Notice how by placing the nondominant hand's third digit in the rectum, the thumb and index finger can still be utilized by the operating surgeon.

The posterior commissure of the vagina is clamped approximately 2 to 3 cm from the midline on the right and left with Allis clamps. A transverse incision is made in between the two Allis forceps. In cases where perineorrhaphy is performed concomitantly, an additional incision is made in the perineum to remove a triangular piece of skin, allowing exposure of the perineal body, as will be discussed in a later section. A vertical incision is made in the posterior vaginal mucosa from the middle of the transverse incision reaching the apex of the rectocele, which is held by an Allis clamp in the midline (Fig. 48.36). Using a Metzenbaum scissors, the vaginal mucosa is dissected from the underlying perirectal fascia using a "snip and push" technique. Once an avascular plane is established, an index finger wrapped with a moist vaginal laparotomy sponge can be used for further dissection, although this technique should be abandoned if significant tissue resistance is met. It is also important to do the dissection close to the vaginal wall side to avoid injuring the rectum. The dissection is extended upward in the midline to well above the bulge of the rectocele (Fig. 48.37). At this point, it is necessary to obtain sufficient hemostasis to identify the anatomic structures.

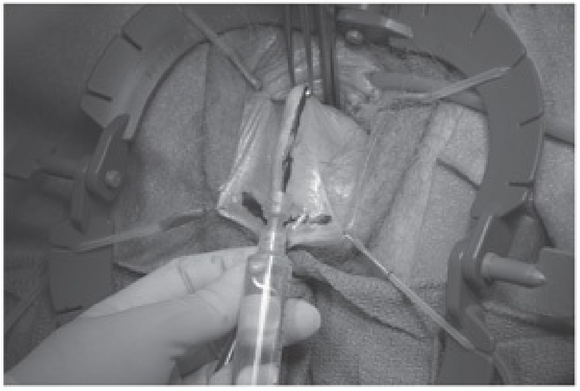

FIGURE 48.36 The proximal end of the rectocele is grasped with an Allis clamp and the midline and transverse incisions are marked. Injection of local anesthetic with epinephrine can help with developing a plane.

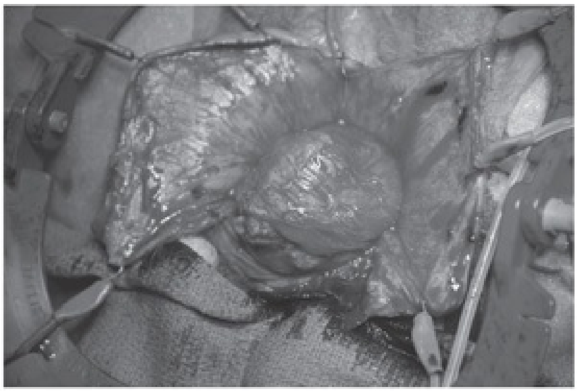

FIGURE 48.37 The vaginal epithelium overlying the rectocele is dissected off using a "snip and push" technique with Metzenbaum scissors held at a 90-degree to the vaginal epithelium. The excess epithelium is removed.

The surgeon then should insert the nondominant middle finger into the rectum, which allows the thumb and index finger to be available to the surgeon. The bulge is reduced to aid in the identification of the lateral rectovaginal fascia. Care is taken not to incorporate the levator ani (levator plication), since this can result in vaginal distortion, constriction, postoperative pain, and dyspareunia (38). The rectovaginal fascia is plicated to the midline using a series of interrupted size 0 polyglactin sutures (Fig. 48.38) that are initially tagged and then tied in succession. The distal end of the rectovaginal septum (imbricated rectovaginal fascia) is then attached to the reconstructed perineal body (perineorrhaphy) if this is performed. Any redundant vaginal epithelium that crosses the midline is excised, and the vaginal epithelium is closed with synthetic absorbable suture (Fig. 48.39).

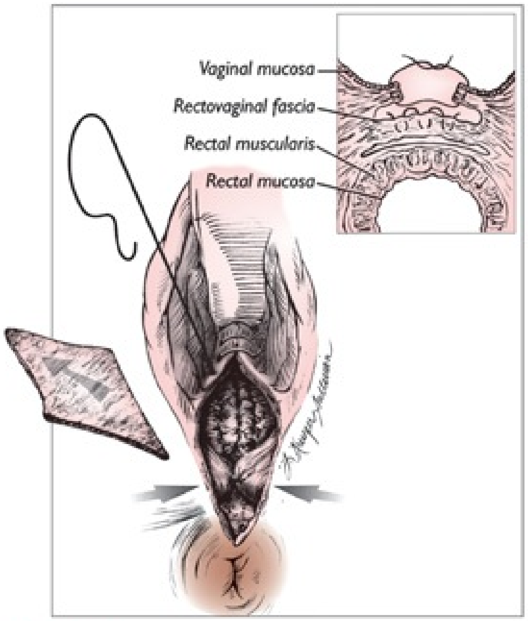

FIGURE 48.38 The rectovaginal fascia is identified lateral to the rectocele. Absorbable interrupted sutures are placed in the rectovaginal fascia bilaterally. The sutures are tied down in succession to re-approximate the tissue in the midline as indicated by the arrows above.

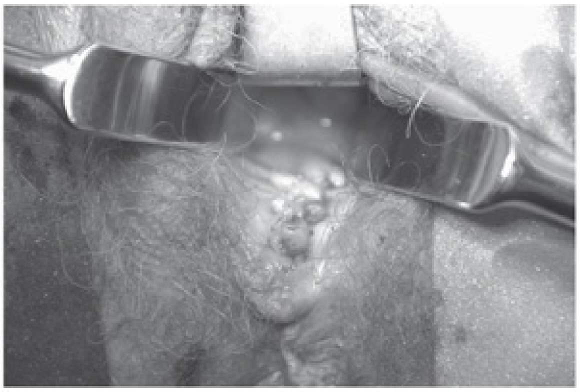

FIGURE 48.39 Examination of the posterior vaginal wall following the posterior repair

Site-Specific Rectocele Repair

The site-specific repair of rectocele was proposed by Richardson et al. (39) in 1976. This technique is based on Richardson et al.'s (39) observations during cadaveric dissection that rectoceles are the result of a specific defect in the rectovaginal fascia.

The initial steps of this procedure are similar to the classic posterior colporrhaphy. The vaginal epithelium is opened and dissected from the underlying rectovaginal fascia. A rectal examination assists in the identification of the edges of the defect, which are grasped with forceps. The defect is repaired with interrupted 0 polyglactin sutures (Vicryl); they are usually placed cranial to caudal, as opposed to the side-to-side placement in a posterior repair. Again, care is taken to avoid the incorporation of any healthy muscle that could result in dyspareunia. If indicated, the perineal body is reconstructed. The vaginal epithelium is closed as previously described.

Reconstruction of the Perineal Body

The perineal body is located between the vaginal introitus and the anus, and attached to it are the following structures: bulbocavernosus muscles, superficial transverse perineal muscles, levator ani muscles, the external anal sphincter, and the rectovaginal fascia (Fig. 48.40). Due to its lateral and superior support, there is limited downward movement of the perineal body. Rectoceles that recur or are symptomatic with defecatory disorders may actually be disorders of exaggerated perineal descent due to the detachment of the perineal body to the rectovaginal septum.

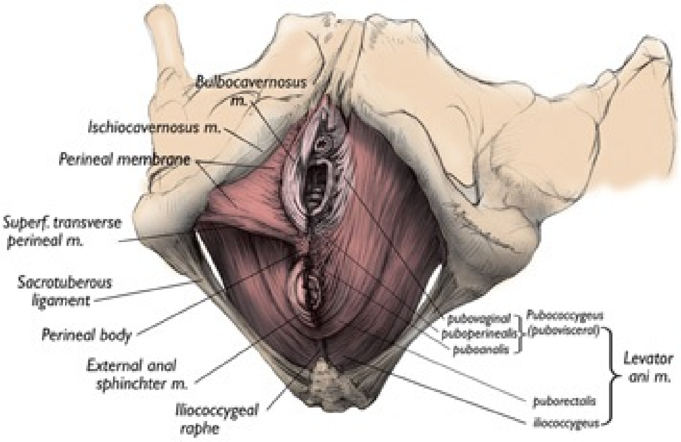

FIGURE 48.40 Inferior view of the pelvic floor. Superficial perineal muscles and perineal membrane have been removed on the left to show attachments of the levator ani (LA) muscles to the distal vagina, anus, and perineal body.

Reconstruction of the perineal body starts with placement of Allis clamps on the lateral edges of the posterior commissure of the vagina that also grasp the underlying bulbocavernosus muscles.

When brought together in the midline, they represent the lower edges of the reconstructed introitus. Care must be taken not to overly narrow the introitus especially because the relaxation of the pelvic floor during anesthesia can often lead to miscalculations in the resulting introitus. A triangular piece of vaginal epithelium is removed so as not to damage the underlying superficial transverse perineal muscles (Fig. 48.41). The bulbocavernosus muscles are plicated with midline interrupted size 0 polyglactin sutures (Fig. 48.42) and the epithelium is closed with a running absorbable suture. Preservation of the size of the genital hiatus is important for women who wish to remain sexually active.

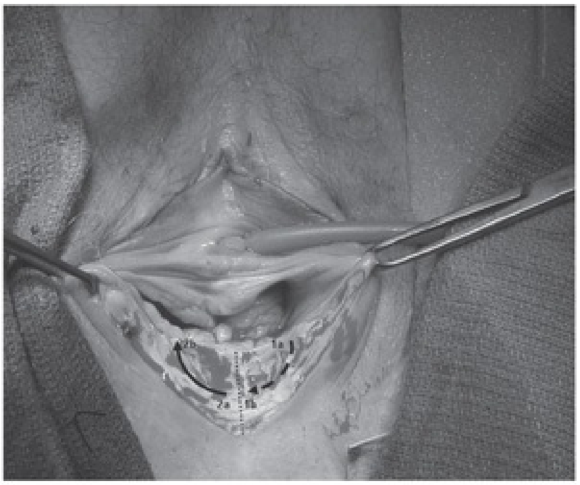

FIGURE 48.41 Perineorrhaphy incision. The perineorrhaphy incision is diamond-shaped and only the epithelium is removed. With a finger in the rectum, interrupted sutures are placed lateral to medial (*1*) with the first pass and then medial to lateral (2) and then tied down.

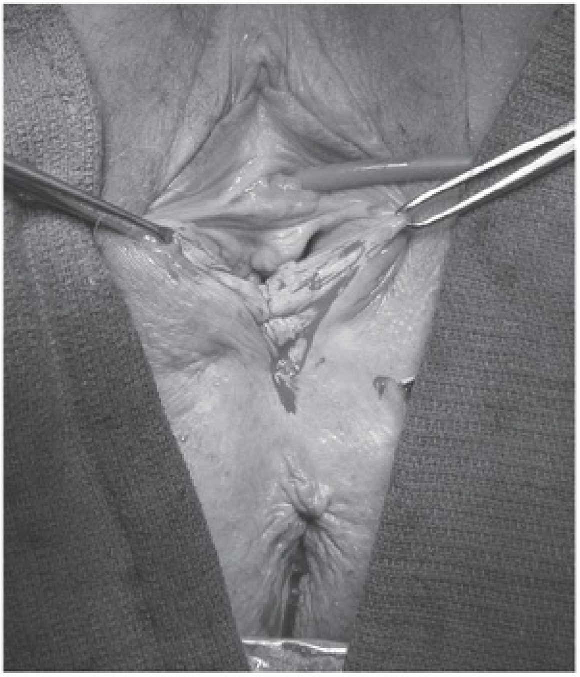

FIGURE 48.42 The perineum after three sutures are placed. The genital hiatus has decreased in size and the perineal body is reconstructed.

POSTOPERATIVE CARE

In our practice, women who have undergone a repair of a posterior vaginal wall defect are admitted to the hospital overnight for pain management and observation. An ice pack to the perineum every couple hours can reduce postoperative edema and pain in women who have had a perineorrhaphy. A voiding trial is typically performed the day of discharge (most often postoperative day 1). A repeat voiding trial is performed by a visiting nurse 3 or 4 days later in the patient's home for those who fail initially. Women are discharged home, to return in 2 weeks, with a bowel regimen consisting of fiber, stool softeners, and a "plan" if they have not had a bowel movement for a couple of days. Oral pain medications, including anti-inflammatory agents and narcotics, may be prescribed. We instruct all women that they are limited to no lifting over 10 pounds and "nothing in the vagina" for 6 weeks.

COMPLICATIONS

The major risks of transvaginally performed apical repair are bleeding due to vascular injury, nerve entrapment, ureteral injury or kinking, bowel injury, wound infection, and persistent or recurrent prolapse. During placement of the purse-string sutures of an enterocele repair, one needs to be aware of the ovarian vessels which lie near the uterosacral–cardinal complexes. The pudendal vessels and nerve, which lie posterior to the sacrospinous ligament, are at risk of injury during sacrospinous ligament fixation. Pudendal entrapment may occur if sutures are placed too laterally, whereas the sciatic nerve is at risk if the sutures are placed too cephalad. Pelvic and gluteal pain, although usually transient, can occur as a result of injury to these nerves. The intrapelvic ureter is intimately associated with the uterosacral ligaments but can be injured or kinked by any of the transvaginal vault suspensions. Administration of indigo carmine and observation of the bilateral efflux is a crucial step for identification of the potential ureteral problem and timely intervention. Ureteral injury or kinking in cases of vault suspension has a reported rate of 1% to 11% (40). Cystotomy, enterotomy, and ureteral injury are the main intraoperative complications specific to the transabdominal apical vault prolapse repair (41).Postoperative complications such as transvaginal mesh erosion, mesh erosion into the bowel, and bowel obstruction also have been reported. As was shown by the CARE trial, mesh erosion after abdominal sacrocolpopexy was 10.5% at 6 years (32).

Significant intraoperative complications occur relatively infrequently with anterior vaginal prolapse repairs. The most common complication seen with cystocele repair is injury to underlying structures such as the urethra, bladder, and rarely, other pelvic viscera, including bowel (42). Incidental cystostomy may be repaired with a layered closure with absorbable suture, and maximization of urinary drainage. Although reported to occur at an incidence of <2%, the prolapse surgeon must always be cognizant of the risk of ureteral damage or obstruction (43). Cystoscopic evaluation intraoperatively should indicate the possibility of ureteral obstruction with non-efflux from one side. Sutures may be removed at this time prior to completion of the procedure. Failure to recognize ureteral injury intraoperatively sets the stage for one of the most devastating complications of anterior or apical prolapse repair.

Postoperative voiding dysfunction may be caused by detrusor overactivity, urethral obstruction, or recurrence of the cystocele. Resolution of preoperative urgency will occur in up to 40% of patients (44); however, de novo detrusor instability will occur in approximately 7% to 12% (44) . Although degrees of urinary retention may occur in patients on a transient basis, prolonged obstruction manifests in <1% of women. Poor or inadequate detrusor contractility may be a reason for incomplete emptying and may be predictable on the basis of preoperative urodynamic evaluation. Persistent dyspareunia, pelvic pain, or vaginal stenosis may ensue from aggressive plication and/or excision of vaginal mucosa.

Constipation and pain are common in the postoperative period after posterior repair. Constipation needs to be addressed early because it may affect success of the surgery. Rectal injury, hematoma, and development of rectovaginal fistula are rare. The most important factor in preventing rectovaginal fistula formation is intraoperative recognition and repair. Dyspareunia was reported in

15% to 27% of cases following the posterior repair in some series (45), yet other studies showed significant improvement of sexual function after the posterior repair (36,46). New-onset bowel dysfunction is reported in 11%.

OUTCOMES

Apical Prolapse Surgery

The results of apical prolapse repair are difficult to evaluate because the definition of success varies between studies and few studies report long-term follow-up. Colombo and Milani (47) found no statistical difference in recurrence of vault prolapse in a retrospective study comparing sacrospinous ligament fixation and McCall culdoplasty (8% versus 3%, respectively). Shull et al. (26) reported "optimal anatomic outcomes" in 87% of patients undergoing uterosacral fixation, whereas Karram et al. (40) reported that 89% of women expressed satisfaction following the procedure. Success rates ranging from 8% to 97% have been reported for traditional sacrospinous ligament fixation (48,49). Shull et al. (50) and Meeks et al. (51) reported 95% and 96% cure rates following iliococcygeus fixation, whereas more recently, Maher et al. (52) reported equal efficacy when comparing the iliococcygeus fixation to sacrospinous ligament fixation.

There are numerous reports by multiple authors that confirm the success of ASC. Success rates >90% have been reported and the durability of this procedure has also been documented (52–54). There are several randomized, prospective trials comparing sacrospinous ligament fixation (SSLF) with ASC (55). In a comparative study between ASC versus vaginal repair, Benson et al. (53) reported a lower success rate with vaginal repair and an equivalent hospital stay between the two groups. Lo and Wang (54) reported on their results of ASC versus SSLF at a duration of 2.1 years: 94.2% success with ASC compared to 80% with SSLF. Maher et al. (56) reported on a comparative study between ASC and SSLF. At 2 years of follow-up, symptoms and anatomic success were equivalent, but asymptomatic failures to introitus and recurrent cystoceles were less after ASC. Overall, vaginal procedures have a higher rate of recurrent anterior defects even when performed in the setting of a concomitant anterior repair (colporrhaphy).

Anterior Prolapse Surgery

Long-term results for these procedures are still undergoing evaluation, but the recently updated Cochrane review provides insightful comparative data on various anterior prolapse repairs (57). Anterior colporrhaphy using native tissue alone is noted to be successful (80% to 100% in some retrospective series) but has high recurrence rate (58–61). Risk factors for operative failure may include advanced age, hormonal depletion, inadequate preoperative identification of all anatomic defects, incomplete surgical reconstruction, or technical failure (62). In addition, obesity, chronic pulmonary disease, bowel dysmotility, and genetic predisposition have also been implicated in surgical failure. Some studies have reported that interpositional grafts convey a significant reduction in prolapse recurrence, with plication repairs demonstrating only a moderate success rates (35,63); however, other authors have found similar objective anatomic outcomes (64,65). Several randomized clinical trials have demonstrated improved anatomic and subjective outcome with synthetic graft augmentation of native tissue repair (66–68). However, these results did not translate to functional outcome using validated questionnaires or reoperation rate. Furthermore, mesh repair was also associated with longer operating time, greater blood loss, and a nonsignificant tendency toward higher cystotomy, de novo dyspareunia, and de novo stress urinary incontinence rate compared with anterior colporrhaphy. However, the possibility of serious mesh complication must be carefully discussed with each patient prior to making any decision in surgical management of anterior compartment prolapse.

Vaginal paravaginal repairs have reported success rates from 67% to 100% at 1 year (69–73). Significant complications have been reported recently with vaginal paravaginal repairs including bilateral ureteric obstruction, retropubic hematoma requiring surgery, vaginal abscesses, and transfusions.

Posterior Prolapse Surgery

Despite the fact that transvaginal posterior colporrhaphies have been the preferred surgical procedure for rectocele repair among gynecologic surgeons for over 100 years, there are few data regarding the long-term anatomic success. In different case series, the anatomic cure rate ranges from 76% to 96% for posterior and from 56% to 100% for site-specific defects (74). One retrospective study compared posterior colporrhaphy and site-specific repair for posterior compartment and noted significantly higher recurrence rate of rectoceles following site-specific repair (32% versus 13% following posterior colporrhaphy) (75). A recent Cochrane review of the surgical management for prolapse reported that transvaginal repair is superior to a transanal approach for posterior vaginal wall prolapse in terms of objective and subjective outcomes (57). The updated Cochrane review also concluded that there was no benefit of mesh augmented repair of posterior compartment.

Posterior colporrhaphy was found to be effective in alleviating symptoms of vaginal bulge (4% to 64%), constipation (22% to 100%), and fecal incontinence (4% to 36%). Thus, the functional improvement is not always correlated with anatomic success.

CONCLUSION

POP is a common yet complex medical condition characterized by herniation of pelvic organs affecting multiple vaginal compartments. Successful restoration of anatomic defects requires expert knowledge of the pelvic floor anatomy and various surgical techniques that can be tailored to meet the needs of each patient.

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SECTION V■ TESTIS, EPIDIDYMIS, VAS DEFERENS, AND SEMINAL VESICLES

Section Editor: MARC GOLDSTEIN

CHAPTER 49■ANATOMY OF THE EPIDIDYMIS, VAS DEFERENS, AND SEMINAL VESICLE

AKANKSHA MEHTA

It is well known that spermatogenesis, the development of germ cells into structurally mature sperm, occurs in the seminiferous tubules of the testis through a series of ordered and well-regulated processes. Less well appreciated is the fact that testicular sperm are functionally immature and therefore incapable of fertilizing an oocyte without direct intracytoplasmic injection (ICSI). Sperm maturation occurs as sperm migrate out of the testis and travel through the male reproductive tract. In their journey, they are supported and stimulated by the distinct microenvironments of the epididymis and vas deferens and bathed in the secretions of the prostate, seminal vesicles, and accessory glands before eventually exiting the male urethra during ejaculation. Physiologic changes that sperm undergo during migration include plasma membrane remodeling, changes in intracellular signaling transduction, and the acquisition of progressive motility, all of which contribute to ultimately rendering spermatozoa capable of oocyte penetration and fertilization. The unique anatomy of the excurrent ductal system, both gross and microscopic, is optimally suited to ensure that sperm maturation progresses in as efficient and as effective a manner as possible. An appreciation of this anatomy is key for understanding not only normal male reproductive physiology but also male factor infertility.

EPIDIDYMIS

Physical Examination

Careful assessment of the epididymides during the physical examination of an infertile patient is as important as the testicular evaluation. The size and consistency of the epididymis can help differentiate between obstructive and nonobstructive etiologies of azoospermia. An enlarged and indurated epididymis suggests obstruction of sperm outflow, whereas a flat epididymis suggests impaired spermatogenesis. Pain upon palpation of the epididymis is concerning for inflammation or infection due to chemical, viral, or bacterial causes, depending on the patient’s history and risk factors. Palpation of a cystic structure originating from the caput epididymis is suggestive of a spermatocele, a diagnosis that is confirmed by documenting the presence of sperm in the aspirate. Although rare, solid tumors originating from the epididymis have been described (1). These may be primary or secondary, benign or malignant, and warrant surgical excision. Absence of the distal epididymis on physical examination should alert the clinician to the possibility of ipsilateral absence of the vas deferens, which, when noted bilaterally, should prompt an evaluation for cystic fibrosis.

Development

The development of the epididymis from the wolffian or mesonephric duct occurs between the 8th and 12th week of gestation under the influence of testosterone produced by fetal Leydig cells (2,3). Specifically, the proximal portion of the wolffian duct differentiates into the epididymis, whereas the distal portion gives rise to the vas deferens. As the cranial end of the wolffian duct degenerates, it leaves behind a small remnant of tissue called the appendix epididymis. During the 9th week of gestation, 5 to 12 nephric ducts in the region of the epididymis make contact with the developing sex cords of the future rete testis. It is not until the third month of gestation, however, that these tubules establish a communication with the rete testis as the efferent ductules (2,4). In humans, the epididymis is well developed by 16 weeks of gestation, and secretory activity of the epididymal cells has been observed by 25 weeks of gestation (5).

The major morphogenic event in epididymal development is the elongation and coiling of the wolffian duct, a process that is likely the combined product of cell proliferation and directed cell rearrangements, and interactions between wolffian duct epithelium and surrounding mesenchymal cells (6).

Anatomy

The epididymis lies posterior and slightly lateral to the testis. It is invested by the tunica vaginalis, which is continuous with the tunica vaginalis covering the testis. Laterally, a deep groove, termed the *sinus epididymis*, marks the boundary between the testis and epididymis. Extensions from this connective tissue sheath enter the interductal spaces, forming septa that divide the tubule into histologically similar regions (7).

Antoine De Graaf, the famous 17th century anatomist, reported his dissection of the human epididymis in 1668, likening the epididymis to a “thin thread which gradually enlarges until it attains the thickness of a piece of string and constitutes the vas deferens” (8). It is estimated that the uncoiled human epididymis measures between 6 and 7 meters in length.

Anatomically, the epididymis is divided into three regions: the caput (head), corpus (body), and cauda (tail) (Fig. 49.1). The caput epididymis is formed by 8 to 12 efferent ducts that originate from the superior pole of the testis and drain into the epididymis. Each efferent duct is 15 to 20 cm in length and opens into an individual epididymal tubule. The epididymal tubules anastomose with one another along the length of the epididymis, eventually becoming a single, coiled tubule in the corpus epididymis. The epididymal tubules are surrounded by contractile smooth muscle cells, which increase in size and number in the distal epididymis. Peristaltic contractions generated by the smooth muscle propel the spermatozoa in an antegrade direction. At its distal end, the cauda epididymis becomes continuous with the convoluted portion of the vas deferens. Here, contractile cells are replaced by smooth muscle organized in three layers—inner longitudinal, intermediate circular, and outer longitudinal—that thicken and continue into the vas deferens.

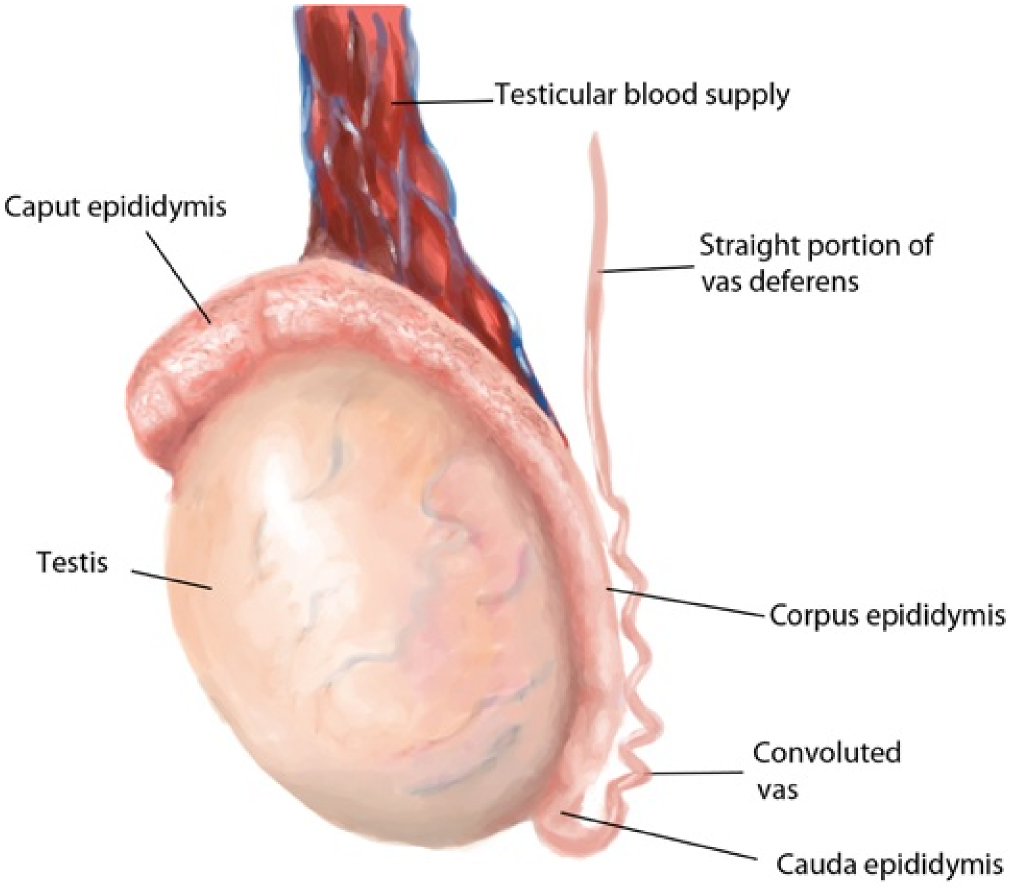

FIGURE 49.1 Anatomy of the testis and epididymis.

The luminal shape and size on cross section of the epididymis varies from the irregular stellate shape in the efferent ducts to the regular, oval, or round shape in the corpus epididymis to the wide irregular shape in the cauda epididymis. Variability in luminal appearance correlates with the different functions performed by each segment of the epididymis and with the different cell types found along its length.

The lumen of the epididymis is lined by nonciliated pseudostratified columnar epithelium and contains four major cell types: principal, basal, apical, and clear cells. Principal cells are tall, columnar cells with basally located, oval nuclei. They bear long stereocilia (15 μm) and function to resorb testicular fluid; approximately 90% of the total secretory fluid volume is absorbed in the epididymis. Principal cells also endocytose other components of seminal fluid and produce glycoproteins that are essential for sperm maturation. Basal cells lie between the principal cells, at their base, and are thought to be precursors of principal cells. Apical and clear cells are far less common than principal and basal cells. Apical cells are rich in mitochondria and most abundant in the caput epididymis. In contrast, clear cells are columnar and most abundant in the caput epididymis. They have few microvilli but numerous endocytic vesicles and lipid droplets. The exact functions of apical and clear cells are unknown.

The composition of epididymal fluid varies along the length of the epididymis, giving rise to several distinct microenvironments within the tubule (9). These are maintained by the active secretion of proteins by the epithelium, fluid reabsorption, and exchange of molecules between the lumen and the circulation. Exchanges are selectively regulated by the blood–epididymis barrier, which is formed by tight apical junctions between adjacent principal cells (10).

The delicate structure of the epididymis makes it vulnerable to iatrogenic injury during procedures such as hydrocelectomy, spermatocelectomy, and orchidopexy, especially if the epididymis is adherent to the tunica vaginalis (11). Additionally, trauma, infection, inflammation, and even prolonged obstruction of the vas deferens, as, for example, after vasectomy, can cause an increase in intraluminal pressure, leading to microscopic ruptures with sperm leakage, sperm granuloma formation at the site of the rupture and, consequently, secondary obstruction of the epididymis.

Blood Supply

The primary arterial supply to the epididymis derives from the testicular artery, with small contributions from the deferential and cremasteric arteries. The testicular artery (also called the internal spermatic artery) arises from the abdominal aorta and courses inferolaterally, under the parietal peritoneum and along the psoas major, toward the pelvis. As the right and left testicular arteries enter the pelvis, they lie anterior to the genitofemoral nerves, ureters, and external iliac arteries. Both arteries then enter the deep internal inguinal ring and travel with the ipsilateral spermatic cord in the inguinal canal to the scrotum. In its course to the testis, the testicular artery branches into an internal artery and an inferior testicular artery and into branches supplying the caput, corpus, and cauda epididymis (12). The level at which this branching occurs is variable; in 31% to 88% of cases, it occurs within the inguinal canal (13,14).

The deferential artery is a branch of the superior (and occasionally inferior) vesical artery, which, in turn, arises from the internal iliac (hypogastric) artery. The cremasteric artery (also called the external spermatic artery) is a branch of the inferior epigastric artery, which accompanies the spermatic cord and supplies the cremaster muscle and other coverings of the cord and the tunica vaginalis surrounding the testis. Both the deferential and the cremasteric arteries enter the inguinal canal at the deep inguinal ring and travel the length of the spermatic cord along with the testicular artery and veins within the scrotum. Rich vascular anastomoses occur at the head of the epididymis, between the testicular and epididymal arteries, and at the tail of the epididymis between the testicular, epididymal, cremasteric, and deferential (vasal) arteries.

Innervation

Sympathetic nerve endings are concentrated in the corpus and cauda epididymis and increase in density in the proximity of the vas deferens, consistent with their role in promoting epididymal contractility. During ejaculation, the distal portion of the epididymis demonstrates intermittent contractions, in contrast to the peristaltic activity of the proximal epididymis (15).

Function

The mean transit time for sperm in the human epididymis is approximately 12 days (16). In addition to providing sperm storage and facilitating sperm transport, the epididymis plays an important role in sperm maturation. Here, spermatozoa undergo a number of physiologic changes, rendering them capable of oocyte penetration and fertilization within the female reproductive tract. The majority of these changes have not been reproduced in vitro, indicating that their triggers have an epididymal origin. Importantly, sperm maturation within the epididymis has been shown to be androgen-dependent (17).

Human spermatozoa acquire an increased capacity for motility as they migrate through the epididymis, which is manifested not only as a quantitative increase in the percentage of spermatozoa with motile tails but also as a qualitative change from an immature to a more mature pattern of motility. Spermatozoa in the proximal epididymis demonstrate high-amplitude, low-frequency tail movements, producing little motion. In contrast, spermatozoa in the cauda epididymis, demonstrate low-amplitude and high-frequency tail movements, resulting in considerably greater forward progression (18). However, the extent to which motility is dependent of the interaction of spermatozoa with a particular section of the epididymis is unknown. In patients with congenital absence or obstruction of the vas deferens, spermatozoa in the distal epididymis demonstrate worse motility compared to spermatozoa in the proximal epididymis (19,20). Therefore, intrinsic sperm processes and the epididymal microenvironment both appear to play an important role in the acquisition of progressive sperm motility.

Sperm undergo restructuring and modification of surface membrane glycoproteins as a result of their interaction with secretory proteins in the lumen of the epididymis (21). These modifications facilitate sperm–zona pellucida binding and the sperm acrosomal reaction (21). Additional morphologic changes, such as migration of the intracellular cytoplasmic droplet, also occur, with important implications for fertility (22).

After microsurgical vasoepididymostomy for epididymal obstruction, pregnancy rates after distal anastomoses are significantly higher than corresponding rates after anastomoses to the caput epididymis (23). Epididymal maturation of sperm therefore appears to be an essential posttesticular stage for acquisition of fertility by the male gamete. Understanding the detailed contribution of the epididymis to sperm function remains an area of active research.

VAS DEFERENS

Physical Examination

The most important aspect of the physical examination of the vasa deferentia is to simply confirm their presence. Approximately 95% of men with cystic fibrosis have congenital bilateral absence of the vas deferens (CBAVD) (24). This condition is characterized by azoospermia and low semen volume (typically less than 1 mL) due to absent or obstructed ejaculatory ducts or hypoplastic seminal vesicles. However, spermatogenesis in these men is usually normal. Absent vasa in these men is usually the only manifestation of cystic fibrosis. In the subset of men with CBAVD who do have a palpable vasal segment in the scrotum, surgical exploration usually reveals a fibrous cord or nonpermeable duct (25,26).

It is recommended that all couples with CBAVD undergo genetic testing, as the vast majority of affected men (70%) have mutations in at least one allele of the cystic fibrosis transmembrane conductance regulator (CFTR) gene that is detectable by routine testing methods (24). Additionally, renal agenesis has been reported in 74% of men with congenital unilateral absence of the vas deferens and in 12% of men with CBAVD (27). Therefore, a renal ultrasound should be performed in the setting of unilateral or bilateral impalpable vasa.

Development

The vas deferens, or ductus deferens, is a tubular structure derived from the mesonephric duct. Normal differentiation of the vas requires exposure to testosterone during embryogenesis. Although vasal agenesis is the most common congenital anomaly, duplications, interdeferential communications, and deferentiomegaly have also been described (28).

Anatomy

As it arises from the cauda epididymis, the vas is tortuous, or convoluted, for the first 2 to 3 cm of its length. Beyond this convoluted segment, the vas lies posterior and parallel to the vessels of the spermatic cord, passes through the inguinal canal, and emerges in the pelvis lateral to the inferior epigastric vessels. At the internal ring, the vas diverges from the testicular vessels, coursing medial to the structures of the pelvic side wall, in order to reach the base of the prostate posteriorly. Here, the vas once again becomes tortuous and dilated, within the segment known as the ampulla of the vas deferens, before culminating at its junction with the seminal vesicle duct, forming the intraprostatic ejaculatory duct (Fig. 49.2).

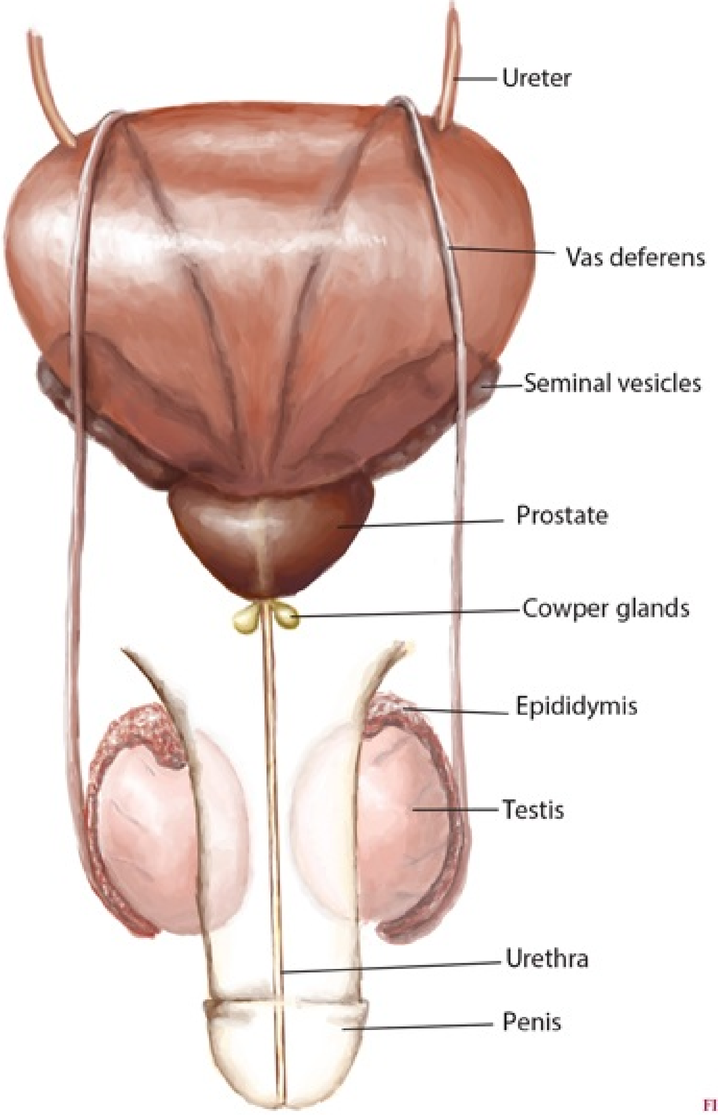

FIGURE 49.2 The male reproductive tract.

In humans, the vas is 30 to 35 cm in length and 2 to 3 mm in outer diameter but with a luminal diameter of only 300 to 500 microns. In cross section, the vas consists of an outer adventitial sheath containing blood vessels and nerves, a thick, muscular wall of outer longitudinal and inner circular smooth muscle lined by elastin, and an inner mucosal lining of pseudostratified columnar epithelium with nonmotile cilia. As such, the vas deferens has the greatest muscle to lumen ratio (approximately 10:1) of any hollow viscous in the human body. During ejaculation, the smooth muscle layers contract reflexively, propelling the sperm in an antegrade direction.

The vas is vulnerable to injury along its entire length, particularly during its course through the inguinal canal. Inguinal hernia repair in adults and children, with and without the use of mesh, is the most common cause of vasal obstruction, with renal transplantation, appendectomy, and hydrocelectomy being other risk factors (29).

Blood Supply

The vas deferens is supplied by the deferential artery, which is usually derived from the superior vesical artery, and occasionally from the inferior vesicle artery, both of which are branches of the internal iliac (hypogastric) artery. Rarely, the deferential artery is derived directly from the internal iliac artery. The deferential artery is surrounded by a dense adrenergic network, and it contracts and relaxes in response to different agonists, demonstrating that it plays an active role in regulating the vasal blood supply (30). Veins from the vas drain into the pelvic venous plexus.

Innervation

The vasa deferentia are innervated by a rich autonomic plexus of primarily sympathetic fibers, which derives from the pelvic plexus. Sympathetic input is important in regulating vasal contraction during ejaculation. Cholinergic nerve fibers supplying the mammalian vas deferens have also been described, albeit lower in density that sympathetic fibers (31). The functional contribution of the cholinergic input to the vas deferens is not well understood at present.

Function

The primary function of the vas deferens is the transport of sperm from the epididymis to the urethra, although absorptive and secretory functions have also been described (32).

SEMINAL VESICLE AND EJACULATORY DUCT

Physical Examination

Palpation of the seminal vesicles provides important information for urologists, both when assessing their involvement in prostate cancer and when assessing for ejaculatory duct obstruction in men with azoospermia and low-volume ejaculate (<1.0 mL). Transrectal ultrasonography can also be used to assess for dilatation of the seminal vesicles, as well as other signs of ejaculatory duct obstruction, such as dilatation of the ejaculatory duct, calcifications within the duct, and the presence of midline cysts. When transrectal ultrasonography is suggestive of ejaculatory duct obstruction, vasography is the only option for confirming the presence of sperm in the vas, confirming the absence of epididymal obstruction, and determining whether or not the obstruction is resectable (Fig. 49.3). Vasography should only be performed at the time of possible reconstruction or transurethral resection of the ejaculatory duct(s).

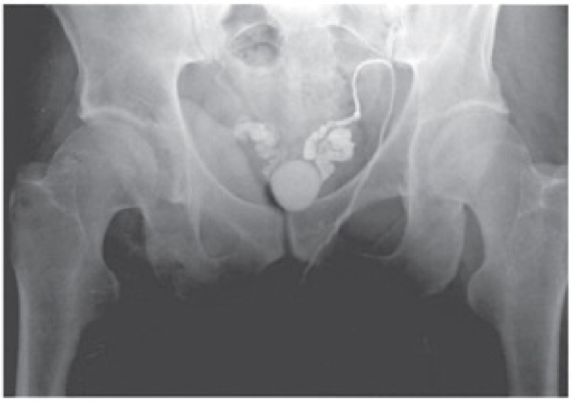

FIGURE 49.3 Intraoperative vasogram demonstrating contrast in the left vas deferens, seminal vesicle, and bladder, indicating patency of the left excurrent ductal system. Residual contrast is seen in the right seminal vesicle from previous performed right vasogram.

Development

The seminal vesicles develop from the caudal end of the wolffian or mesonephric ducts. This simple tube branches into a lobular structure during its development, organizing into a collection of ducts that drain into a principal excretory duct. In humans, the seminal vesicles are relatively undifferentiated during infancy and adolescence. Following puberty, under the action of circulating testosterone, their cuboidal epithelium is replaced by glandular epithelium, which is reflective of their secretory role and contribution to the composition of semen volume.

Anatomy

The seminal vesicles are paired glands positioned below the bladder and lateral to the vasa deferentia (Fig. 49.4). In adults, the seminal vesicle measures between 5 and 10 cm in length, and 3 and 5 cm in diameter, with an average volume capacity of 13 mL (33). In the majority of men, the right seminal vesicle is slightly larger than the left; however, the size of both glands decreases with age.

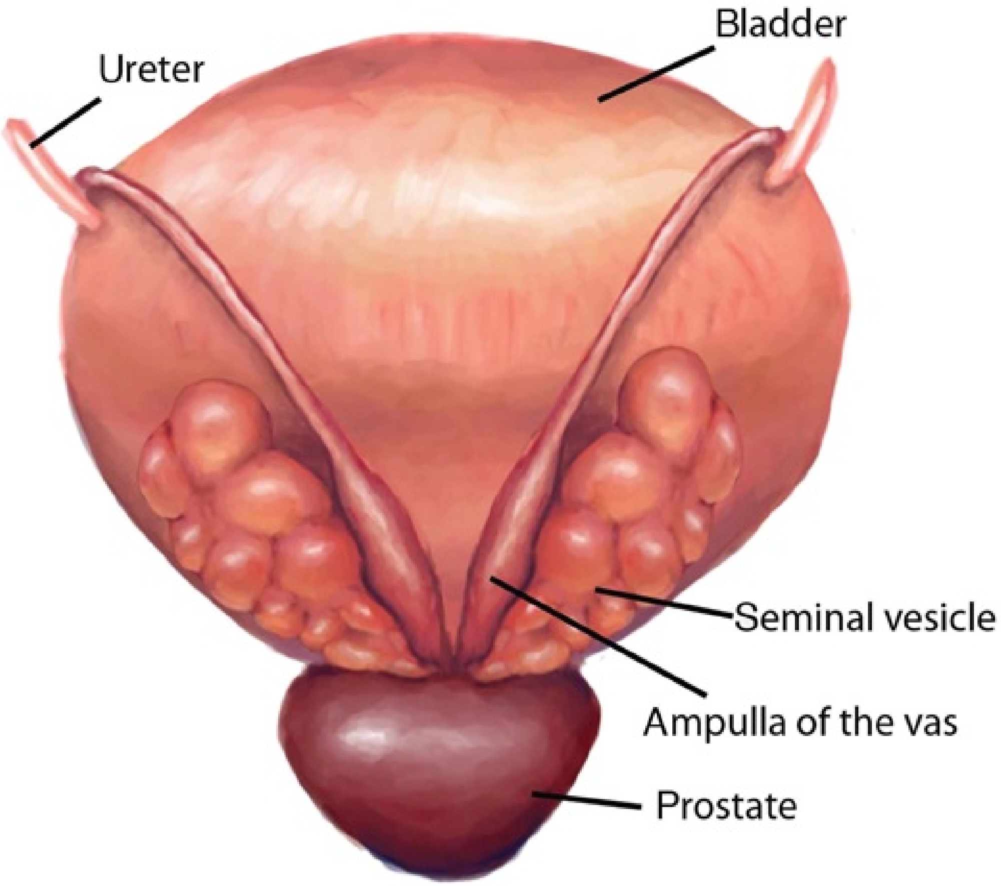

FIGURE 49.4 Posterior view of the bladder and seminal vesicles.

In essence, each seminal vesicle is a coiled tube with irregular diverticula, contained within a dense, fibromuscular sheath and partly covered by peritoneum. The wall of the seminal vesicle is composed of an external connective tissue layer, a middle smooth muscle layer (significantly thinner than the corresponding layer in the vas deferens), and an inner mucosal layer with a highly folded, labyrinthine structure. The mucosal layer is lined by cuboidal to pseudostratified columnar epithelium, featuring typical protein-secreting cells.

The upper pole of the seminal vesicle is a cul-de-sac, whereas the lower pole narrows to a straight duct, which, along with the vas deferens, culminates as the ejaculatory duct. The seminal vesicles are intimately associated with the prostate and bladder anteriorly, the distal ureter superiorly, and the rectum and Denonvilliers fascia posteriorly. The ampullae of the vas deferens lie along the medial margins of the seminal vesicles, whereas the veins of the prostatic venous plexus lie laterally.

The duct of the seminal vesicle unites with the ampulla of the ipsilateral vas, giving rise to the paired ejaculatory ducts. Each ejaculatory duct is approximately 2 cm in length and extends from the base of the prostate, between the median and lateral lobes, toward its opening on the verumontanum. The ducts diminish in size and converge toward their ends. Ejaculatory duct obstruction, although rare, can lead to oligospermia or azoospermia. Causes of ejaculatory duct obstruction include congenital cysts, such as müllerian duct cysts, chronic or acute severe prostatitis, or iatrogenic injury during urethral manipulation or even prostate biopsy.

In contrast to the walls of the vas and seminal vesicles, the walls of the ejaculatory ducts are thin. They contain an outer fibrous layer, which decreases in thickness upon their entry into the prostate, a thin layer of smooth muscle fibers arranged in an outer longitudinal and inner circular orientation, and a mucosa lined by columnar epithelium. The ducts dilate during ejaculation. Normal luminal and wall dimensions of the ejaculatory duct are remarkably uniform among men (34). A luminal diameter of greater than 2.3 mm defines a dilated or obstructed efferent duct (34).

Blood Supply

The primary blood supply to the seminal vesicles is from the vesiculodeferential artery, a branch of the umbilical artery (35). A second source of blood supply is the inferior vesical artery, which arises from the internal iliac (hypogastric) or the inferior gluteal artery. Venous drainage is provided by the vesiculodeferential veins and the inferior vesical plexus.

Innervation

The seminal vesicles receive parasympathetic input from the pelvic nerve and both sympathetic and parasympathetic input from the hypogastric nerve.

Function

The seminal vesicles produce a viscous white-yellow fluid, which contributes to at least two-thirds of the total ejaculate volume. The secreted fluid is rich in fructose, coagulation proteins, and prostaglandins, with a pH in the neutral to alkaline range. Seminal vesicle secretions play an important role in sperm motility and metabolism. Specifically, seminal plasma prevents sperm agglutination, promotes semen coagulation, stabilizes the sperm cytoplasmic membrane and sperm chromatin, and suppresses immune activity in the female reproductive tract (36). Contrary to what their name suggests, the seminal vesicles are not reservoirs for spermatozoa, except in cases of ejaculatory duct obstruction. They contract during ejaculation to release secretions into the ejaculatory duct.

ACCESSORY GLANDS

Prostate

Although an important organ of the male reproductive tract, the prostate is featured in its own chapters and will not be reviewed here.

Bulbourethral (Cowper) Glands

The bulbourethral glands, also known as Cowper glands, are small, round, yellow, lobulated structures, measuring approximately 1 cm in diameter. They lie lateral to the membranous urethra and superior to the perineal membrane (Fig. 49.5). They are drained by long excretory ducts, each duct being almost 3 cm in length, which pass obliquely and anteriorly from the region of the membranous urethra, penetrate the perineal membrane, and open on the floor of the bulbar urethra, approximately 2.5 cm below the perineal membrane (37).

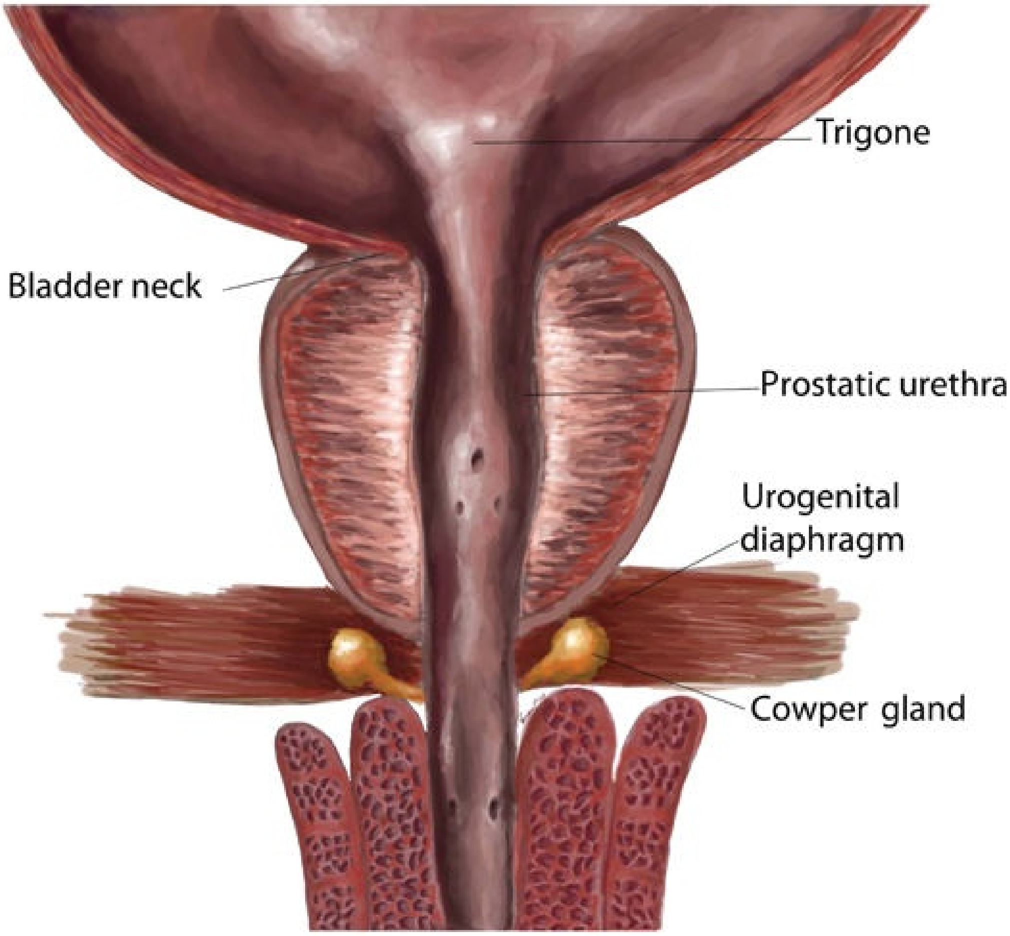

FIGURE 49.5 Anatomy of the urethra.

The glands themselves are surrounded by fibers of the sphincter muscle. During sexual excitement, contraction of the sphincter muscle fibers leads to expulsion of clear mucus from the glands into the bulbar urethra. Secretions of the bulbourethral glands comprise 5% to 10% of the total ejaculate volume.

Each bulbourethral gland consists of several lobules held together by a fibrous capsule. The secretory units are tubuloalveolar in form. The glandular epithelium is columnar and secretes acidic and neutral mucins into the urethra prior to ejaculation. These secretions primarily have a lubricating function. Diffuse mucosa-associated lymphoid tissue (MALT) is associated with the glands (37).

Blood supply to the bulbourethral glands derives from the artery of the bulb of the penis as well as the internal pudendal artery, the urethral artery, and the perineal artery. Primary innervation of the smooth muscle of the accessory glands consists of adrenergic fibers arising from the ipsilateral pelvic plexus.

Periurethral Glands

The periurethral glands, also known as the glands of Littre, are most numerous in the penile urethra. Like the bulbourethral glands, these secrete mucus into the lumen of the urethra prior to ejaculation. Their secretions, too, primarily have a lubricating function.

SUMMARY

The anatomic features of the epididymis, vas deferens, and seminal vesicle reflect their function in male reproductive physiology. An understanding of the anatomy of the excurrent ductal system facilitates the physical examination, diagnostic workup, and medical and surgical management of male fertility disorders.

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CHAPTER 50 SEMINAL VESICLE AND EJACULATORY DUCT SURGERY

BROOKE A. HARNISCH AND JAY I. SANDLOW

SEMINAL VESICLE SURGERY

The seminal vesicles are paired male organs with no female homologue. They develop as a dorsolateral bulbous swelling of the distal mesonephric duct at approximately 12 fetal weeks. The seminal vesicle and the ampulla of the vas join posteriorly and superiorly to the prostate to form the ejaculatory duct at 13 weeks of life. The blood supply to the seminal vesicle is from the vesiculodeferential artery, a branch of the umbilical artery. Venous drainage is from the vesiculodeferential veins and the inferior vesical plexus. The seminal vesicles are innervated by the pelvic nerve and the hypogastric nerve. The hypogastric nerve sends both adrenergic and cholinergic fibers to the seminal vesicles. Lymphatic drainage is via the internal iliac nodes (1).

Primary pathology within the seminal vesicles is rare; secondary lesions are more common. In the past, insufficient imaging methods led to infrequent definition of either primary or secondary seminal vesicle pathology. The use of transrectal ultrasonography (TRUS), computerized tomography (CT), and magnetic resonance imaging (MRI) has improved diagnostic visibility and facilitated the diagnosis and treatment of seminal vesicle pathology. The necessity of surgical intervention is rare, but indications include congenital cysts with infection and/or obstruction causing infertility, ureteral ectopy into a seminal vesicle with resultant obstruction or dysplasia of the ipsilateral kidney, and primary tumors, either benign or malignant. Surgical access to the seminal vesicles is mostly via routes familiar to the urologic surgeon, but surgery on the seminal vesicles alone (without adjacent organ removal) is a unique challenge.

Diagnosis

The normal seminal vesicle on TRUS is an elongated, flat, paired structure between the rectum and the bladder just superior to the prostate and is typically not palpable on digital rectal examination. The diagnosis of seminal vesicle neoplasms can be difficult because they often do not cause symptoms until late in their course. General symptoms that may occur include urinary retention, dysuria, hematuria, or hematospermia. A mass is often palpable above the prostate and is usually not tender. TRUS is usually the next step in diagnosis and may be accompanied by needle aspiration or biopsy for diagnosis. CT or MRI would then be appropriate to stage the patient and may also be used to stage solid lesions within the pelvis as well as to confirm the hemorrhagic nature of suspicious masses. Because prostate cancer may be mistaken for primary seminal vesicle cancer, serum prostate-specific antigen (PSA), as well as tissue immunohistochemical stains for PSA, should, if positive, help define the prostate as the site of primary malignancy. In infertile patients who present with azoospermia, or in patients with hematospermia or coital pain, TRUS is the initial imaging study. Contrast vasography accurately images the vas deferens and ampullary–seminal vesicle junction but is less reliable than TRUS for seminal vesicle pathology.

Alternative Therapy

There are relatively few alternatives to treatment of seminal vesicle masses, unless they are infected. Antibiotics may be utilized in this case. Many of the benign masses are asymptomatic and may be observed. Ejaculatory duct obstruction can also be observed if fertility is not an issue or if the couple desires sperm acquisition with in vitro fertilization.

Indications for Surgery

Treatments of conditions of the seminal vesicles alone are limited to (a) transperineal/transvesical aspiration of seminal vesicle cysts or abscesses, (b) transurethral unroofing of seminal vesicle cysts or abscesses, (c) laparoscopic or robotic dissection, and (d) open resection of one or both seminal vesicles.

Most procedures performed on the seminal vesicles are related to radical surgery for the treatment of urethral, prostate, bladder, or rectal cancer. Treatments specific to the seminal vesicle include transrectal aspiration of cysts or abscesses, transurethral unroofing of abscesses and obstructing cysts, and open resection for refractory infections, to excise an ectopic ureter or to remove benign or malignant masses.

If a solid lesion identified in the seminal vesicle shows no evidence of local spread and is benign on biopsy, treatment is dependent on symptoms. If the patient is asymptomatic, close follow-up consisting of repeat rectal examination and TRUS to determine subsequent growth of the tumor is reasonable. If the mass enlarges or if the patient has symptoms referable to the mass, simple seminal vesiculectomy is advisable. This may be accomplished through one of several routes described in the following text. If the mass is quite large and solid and demonstrates questionable margins, or if the biopsy shows malignant cells, the treatment of choice is quite different. Because fewer than 10 cases of primary tumors of the seminal vesicles have been treated at any one institution, it is difficult to define optimal treatment with any degree of certainty. Radical excision, which usually includes a cystoprostatectomy with pelvic lymphadenectomy, is the treatment of choice unless the tumor is extremely small. This recommendation is based on the extensive nature of the majority of the cancers when detected. The excision may include the rectum (total pelvic exenteration) if it is thought to be invading the surrounding structures. Adjuvant therapy has no proven efficacy, although the only long-term survivors in the literature received radical surgery with subsequent pelvic radiation therapy or androgen deprivation therapy. No chemotherapeutic regimen is known to be efficacious (2–4).

Surgery

The most useful open surgical methods include transperineal, similar to radical perineal prostatectomy; transvesical, achieved by incising through the posterior bladder wall; paravesical; retrovesical; or transcoccygeal. Over the past decade, the laparoscopic or robotically assisted approaches to benign seminal vesicle lesions have been found to be remarkably direct and associated with much less postoperative morbidity than the open surgical approach (5). The choice of surgical approach, of course, depends partly on the characteristics of the lesion to be treated but probably more on the experience and expertise of the surgeon. For the most part, congenital lesions require an abdominal approach so that the ipsilateral kidney can be dealt with concomitantly, if necessary. Such lesions may be dealt with by laparoscopic or open surgical intervention. Benign lesions may be approached perineally; however, the risk of impotence is high even if a nerve-sparing approach is attempted. Larger benign tumors or cysts are best handled by an anterior abdominal approach, although a transcoccygeal method may be as useful. Again, the transperitoneal or retroperitoneal laparoscopic approach has great merit for such lesions. Patients with malignancy require radical extirpation, which commonly includes cystoprostatectomy, seminal vesiculectomy, and pelvic lymphadenectomy. This operation is no different from a routine procedure for bladder cancer and thus is not described here.

Preoperative Preparation

Preoperative preparation for laparoscopic, robotic, or open seminal vesicle surgery depends on the extent of the pathology and the planned incision. Transperineal, transcoccygeal, and transvesical approaches should be prefaced by a complete bowel preparation. Most surgeons use a mechanical preparation with GoLYTELY orally the evening before surgery, followed by the standard antibiotic bowel regimen. Some method to prevent phlebothrombosis in the legs, such as use of intermittent compression stockings during and immediately after surgery, is advisable.

Surgical Technique

A variety of surgical approaches to the seminal vesicles have been described, of which the most useful are the transvesical, transperineal, and laparoscopic.

Transvesical Approach

The transvesical approach to the seminal vesicle has been described by numerous authors (6). It is often used for large benign/cystic masses and cases where there is an ectopic ureter draining into the seminal vesicle. It allows for easy accessibility to the kidney, ureter, and bladder. A midline extraperitoneal suprapubic incision is made up to the umbilicus, and the rectus muscles are separated on the midline. The space of Retzius is opened by downward displacement of the transverse fascia on the pubis, and an Omni retractor is placed to expose the anterior bladder wall. Care is taken during this dissection not to injure the epigastric vessels on either side of the pubis. The bladder is opened longitudinally approximately 7 to 10 cm, ending 2 to 3 cm away from the bladder neck. Moist 4 × 8 sponges are placed on the bladder wall laterally and at the dome of the bladder, and specialized blades are placed to put the open bladder on stretch. Although it is not necessary, it is preferable to place long 8Fr feeding tubes in the ureters at this point to define the orifices and to help with identification of the subtrigonal ureters to prevent their injury later in the dissection. Using a Bovie cutting stylet, a vertical incision is made through the trigone on the posterior midline approximately 5 cm in length

(Fig. 50.1A). Alternatively, a transverse incision just above the bladder neck can be used, but it is not preferred. The vertical incision is deepened through the bladder muscle, and the ampullae of the vas should be recognized directly beneath the bladder neck. They can be dissected by scissors down to their entrance into the prostate and then either ligated and divided or left intact, depending on the pathology, as described in the perineal approach. Just lateral to the ampullae on the prostate base, the seminal vesicles should be identified and the plane surrounding them entered easily unless there has been prior inflammatory disease (Fig. 50.1B). The seminal vesicles should be encircled and dissected completely free. Metal clips should be placed on the vascular pedicle and a 2-0 chromic tie on the distal end at the prostate. A clip is placed across the proximal end of the vas to prevent seminal vesicle contents from obscuring the field, and then the vesicle is transected and removed. If there is a moderate-sized cyst, the dissection is more involved but is usually made simple because the perivesical plane is usually more pronounced. The plane may be very difficult to establish if there was prior vesiculitis, and in this instance, the ureteral catheters are a welcome safeguard—care must be taken not to dissect completely through Denonvilliers fascia posteriorly and into the rectum. The posterior bladder incision is then closed with a running 2-0 absorbable suture in the muscle layer, followed by a running 4-0 absorbable suture in the mucosal layer. The ureteral stents and 4 × 8 sponges are removed, a 20Fr urethral catheter is placed, and the anterior bladder wall is closed similarly to the posterior wall. Suprapubic tube placement is an option but is not necessary. A suction drain is placed through a separate stab incision and positioned in the prevesical space away from the suture line. The urethral catheter is typically removed in 5 to 7 days. This approach is more prone to blood loss and ureteral injury than the perineal approach, but a rectal laceration is much less likely.

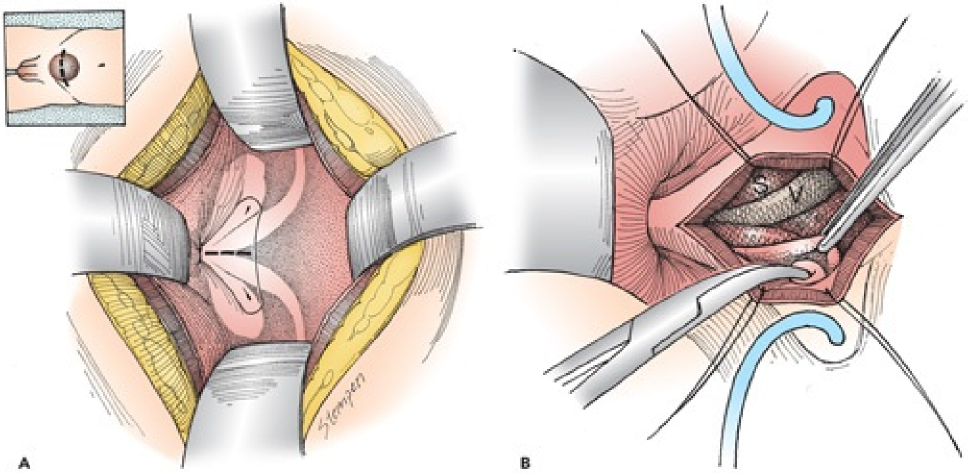

FIGURE 50.1 The transvesical approach to the seminal vesicle. A: Vertical incision in the trigone to expose the retrovesical seminal vesicle. *Inset*, line of incision. B: Dissection of the vas ampullae (*V*) and seminal vesicles (*S*).

Transperineal Approach

The transperineal approach to seminal vesiculectomy is virtually identical to radical perineal prostatectomy, described in Chapter 32. An exaggerated dorsal lithotomy position is used to elevate the perineum so that it is parallel to the floor. An inverted U incision is made in the perineum and the central tendon is divided (Fig. 50.2A). An anterior retractor stretches the rectal sphincter superiorly, allowing visualization of the glistening anterior rectal fascia fibers. The rectourethralis is divided near the prostatic apex and a weighted speculum is placed, dropping the tented rectum. To adequately expose the seminal vesicle, the rectum should be dissected off the posterior surface of the prostate to a point higher than that needed for perineal prostatectomy. Denonvilliers fascia is then incised transversely or in the midline (if nerve-sparing) on the prostate near the base of the seminal vesicles.

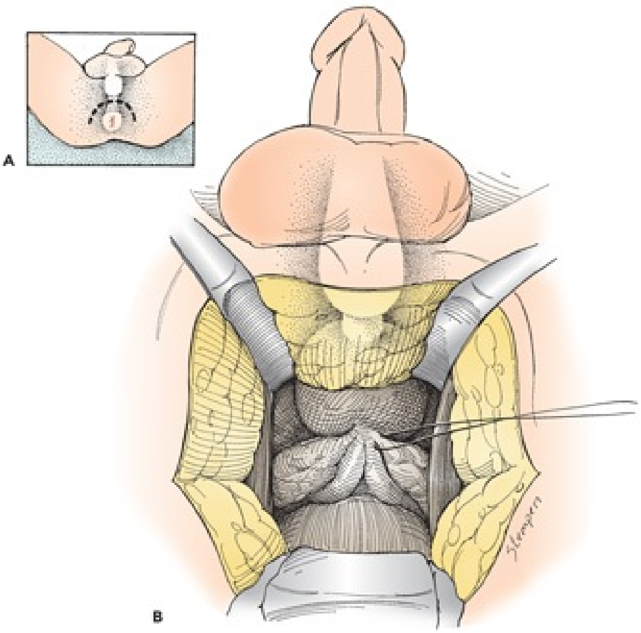

FIGURE 50.2 The transperineal approach. A: Inverted U-shaped incision in the perineum with takedown of the central tendon. B: Exposure and ligation of the seminal vesicles after incising Denonvilliers fascia.

Seminal vesicle dissection is facilitated by posterior traction on the prostate provided by placement of a Lowsley retractor in the bladder. Medially, the ampullae and seminal vesicles are apparent after Denonvilliers fascia is incised (Fig. 50.2B). The ampullae can be spared for the excision of a simple seminal vesicle cyst or small tumor but may need to be resected in the setting of cancer or infection. After dissection of the seminal vesicle at the prostatic base, an absorbable tie of 2-0 suture is used to ligate the gland (see Fig. 50.2B). Before division of the seminal vesicle, a clip is placed on the cut end of the organ to minimize spillage. An Allis or Babcock clamp is then placed on the freed base of the seminal vesicle to ease the apical dissection. The vascular pedicle at the apex of the gland is usually observed within 1 cm of the tip and is ligated with small metal clips, allowing gland removal. The wound is closed in layers as outlined for perineal prostatectomy. A Penrose drain is left in the area of dissection for 24 hours or until no drainage is noted. This approach is well tolerated, and patients are usually discharged within 24 to 48 hours of surgery.

Paravesical and Retrovesical Approaches

The paravesical incision is used in children, when there is a large unilateral cyst that lies lateral to and above the bladder and when nephroureterectomy is required. A midline or Pfannenstiel extraperitoneal suprapubic incision is made. The bladder is finger-dissected away from the lateral pelvic sidewall on the affected side. The vas deferens is identified, placed on tension, and dissected down toward the base of the bladder. If the seminal vesicle mass is distended, it should be visible rather quickly as the vas comes close to the bladder posteriorly. Placing a catheter in the bladder and emptying it usually allows the plane between the bladder and the cyst to be readily identified. The plane is incised with scissors, and the seminal vesicle cyst is carefully dissected away sharply. When the tip of the cyst is clearly identified, a 1-0 chromic suture is placed into it to provide traction, making further dissection easier. As the dissection proceeds, it must be remembered that the ureter crosses the vas and must be identified to prevent its injury. In addition, the superior vesicle artery and perhaps the inferior vesicle artery may be sacrificed to gain access to the base of the seminal vesicle. This will cause no harm and should be done without major concern. As the dissection proceeds, the bladder is progressively rolled over medially, and the mass is dissected away from the bladder laterally. The plane is easily maintained with sharp dissection. Any vessels feeding the seminal vesicles should be suture-ligated or metal-clipped. As the prostate is approached, caution must be used to stay directly on the mass so as not to injure the neurovascular bundle lying just lateral to the seminal vesicle. At the prostate base, the neck of the seminal vesicle is encircled and ligated with a 2-0 absorbable suture. A clamp is placed across just distal to the tie, and the seminal vesicle is severed. There may be no need to clip the vas. A suction drain is placed in the bed of the seminal vesicle and brought out through a separate stab incision. The wound is then closed in layers. Postoperative care is as previously described, except with this approach, the drain can be removed within 24 hours if there is no drainage, and the urethral catheter can be removed within 24 hours. The patient may be discharged within 2 to 3 days. Complications include ureteral injury and excessive blood loss. If the principles outlined earlier are followed, these are unlikely events.

The retrovesical approach should be considered in patients requiring bilateral excision of small seminal vesicle cysts or benign masses (7). A midline suprapubic incision is made into the peritoneal space (Fig. 50.3A). A catheter is placed, and the urine is evacuated. The reflection of the peritoneum over the rectum at the posterior bladder wall is incised transversely, with care taken not to incise into the rectum (Fig. 50.3B). The bladder is peeled back from the rectum progressively with sharp dissection until the ampullae of the vasa and the tips of the seminal vesicles come into view (Fig. 50.3C). The seminal vesicles are dissected down to the base of the prostate, much as described in the transvesical approach, and the neck of the seminal vesicle is ligated and divided bilaterally. The ampullae are usually not taken unless necessary. A suction drain is left in the area posterior to the bladder and brought out as before. Postoperative care is as per the description for a paravesical resection. Complications include rectal injury, bladder laceration, and hemorrhage. In this situation, a rectal injury would be within the peritoneum well above the levator ani muscles. After a two-layer closure as before, strong consideration should be given to placement of omentum over the closure between the bladder base and the rectum as well as to a temporary colostomy.

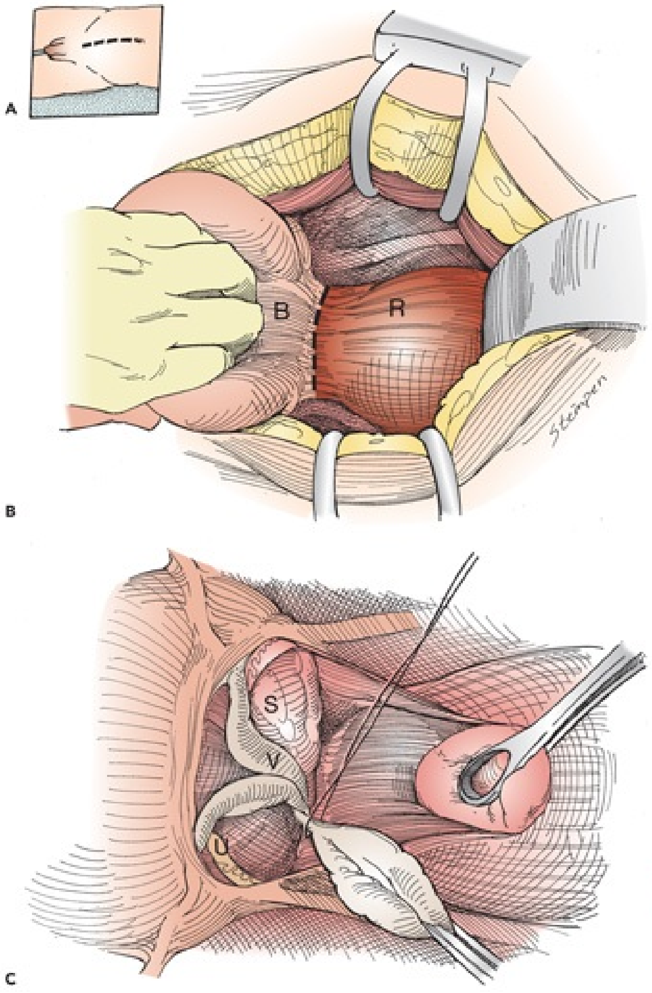

FIGURE 50.3 The retrovesical approach. A: Midline infraumbilical incision (*broken line*). B: Incision of the posterior peritoneum over the rectum (*R*) in the cul-de-sac. *B*, bowel. C: Exposure of the vas ampulla (*V*) and seminal vesicle (*S*) behind the bladder. *U*, ureter.

Transcoccygeal Approach

The transcoccygeal approach may not be familiar to most urologic surgeons and is unlikely to be a common choice owing to fear of rectal injury and impotence. In individuals for whom the perineal or supine position may be difficult to maintain, or who have had multiple suprapubic or perineal surgeries, the transcoccygeal approach may be very useful. The patient is placed on the table, ventral side down (prone), and in a relative jackknife position (8,9). The incision is made in an L shape from midway on the sacrum (10 cm from the tip of the coccyx) and angled at the tip of the coccyx down the gluteal cleft within 3 cm of the anus (Fig. 50.4A). The incision is carried down to the lateral side of the coccyx, which is dissected free from the underlying rectum and eventually totally removed. The gluteus maximus muscle layers are moved aside, and the rectosigmoid is encountered and dissected carefully from the underside of the sacrum. With careful dissection, the lateral wall of the rectum on the side of the lesion is dissected medially from the levator ani muscle and surrounding tissue until the prostate is encountered. It is possible that the neurovascular bundle will be recognized from this approach. Once the prostate is palpated, dissection of the tissue directly superior to the base on the midline should reveal the ampulla of the vas and, lateral to it, the seminal vesicle (Fig. 50.4B). If difficulty dissecting the rectum away from the prostate is encountered, a finger in the anus via an O’Connor sheath will allow the correct plane to be determined. Dissection and removal of the seminal vesicles should follow the principles outlined previously. A Penrose drain should be left in the area, exiting through a separate stab incision at closure. The rectum should be carefully scrutinized for injury; if any injury is found, it is closed in two layers. The wound is closed in layers as well. Postoperative care does not differ from that previously described; similar to the perineal approach, the patient should have a rapid and easy recovery. The drain should be removed within 2 to 3 days if there is no drainage.

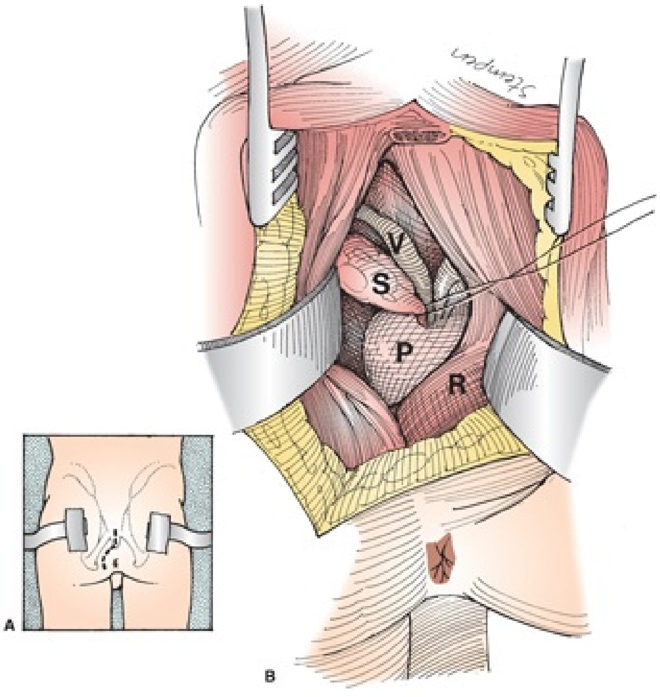

FIGURE 50.4 The transcoccygeal approach. **A:** The incision (*broken line*) is made over the coccyx and curved along the gluteal cleft. **B:** Denonvilliers fascia is incised deep to the rectum (*R*) to expose the prostate (*P*) and seminal vesicles (*S*). *V*, vas ampulla.

Laparoscopic Technique

Most laparoscopic surgery performed on the seminal vesicles has been in conjunction with radical prostatectomy, which was first described by Kavoussi et al. (10). It is known that dissection of the ampulla of the vas and seminal vesicles is a challenging part of a perineal prostatectomy, and thus, prior mobilization of these structures made this easier. Its application for benign seminal vesicle pathology is limited to case reports or small series (6).

Patients are placed supine with the arms carefully padded and tucked in by the sides. Access to the perineum is usually not necessary for benign seminal vesicle pathology, whereas if a laparoscopic or robotic prostatectomy will be performed in addition, the legs are abducted but left straight with the use of an operating table that allows a split-leg arrangement. If possible, the low lithotomy position is avoided so as to minimize the risk of lower extremity thrombosis or neuromuscular injury. Patients are carefully strapped to the operating table with wide cloth tape across the chest and thighs as steep Trendelenburg (approximately 20 degrees) is required for deep pelvic laparoscopic visualization. After the patient is prepared and draped, a Foley catheter is inserted into the bladder under sterile conditions. An orogastric tube placed in the stomach is optional.

A transperitoneal approach is preferred for benign seminal vesicle lesions. After establishing a suitable pneumoperitoneum up to 15 mm Hg with the Veress needle placed at the inferior or superior umbilical crease, four laparoscopic ports are usually adequate for seminal vesicle benign pathology excision. These ports, varying from 5 to 12 mm in size, may be placed in a diamond shape (Fig. 50.5) or a horseshoe shape. With the patient in steep Trendelenburg, the peritoneum just anterior to the rectum in the rectovesical pouch (pouch of Douglas) is incised transversely between the two obliterated umbilical ligaments. Large seminal vesicle cysts are usually easily visualized, and the dissection is carried close to the seminal vesicles so as to avoid injury to surrounding viscera and the neurovascular bundle. Use of bipolar coagulation is highly recommended over monopolar energy so as to minimize injury to these surrounding structures. The dissection can be completed using laparoscopic scissors and curved graspers using blunt and sharp dissection. The main arterial branch to the tip of the seminal vesicle is easily handled with bipolar coagulation, but a laparoscopic clip is also a good choice. The seminal vesicle should be dissected caudally down to its juncture with the ampulla of vas and then clipped en bloc. With completion of the dissection, the specimen is placed in an entrapment device (LapSac, Cook Urological Inc, Spencer, Indiana) or an Endo Catch bag (U.S. Surgical, Tyco Healthcare, Norwalk, Connecticut) and extracted through one of the larger laparoscopic ports. Large cysts may be aspirated prior to extraction so as to minimize the specimen size and obviate the need for enlarging the incision. Hemostasis and surrounding visceral integrity are assured and then the laparoscopic ports are closed in the usual fashion.

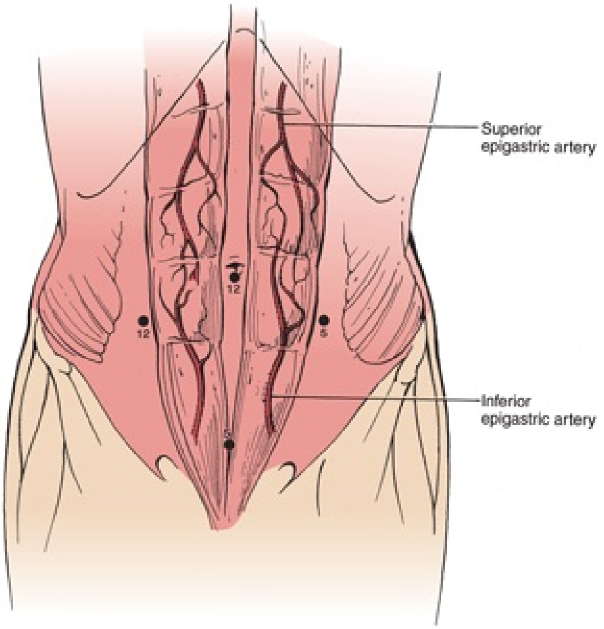

FIGURE 50.5 Optimal sites (*black spots*) of access for transabdominal laparoscopic seminal vesicle excision. Numbers represent trocar size in millimeters.

Laparoscopic/robotic approach to the seminal vesicles can also be approached in an extraperitoneal fashion. This technique was first described in the setting of radical prostatectomy. Despite being technically challenging, this method is often used in obese patients and those with prior abdominal surgeries. Patient positioning is similar to transperitoneal approach. However, a 1.5-cm paraumbilical incision is made and blunt dissection of the rectus muscle is completed, allowing for the initial preperitoneal space to be developed. A balloon trocar is then introduced and the preperitoneal space is further dilated under direct vision. A 15-mm trocar is inserted at the level of the umbilicus. Insufflation of the extraperitoneal space is achieved. The remaining trocars are placed similar to the description earlier. Seminal vesicle dissection takes place after the bladder neck dissection. The bladder neck is retracted cephalad, exposing the anterior layer of Denonvilliers fascia. A small incision is made at this layer approximately 5 cm from the base of the prostate. The ampulla of the vas deferens and seminal vesicles are then visualized, and dissection is initiated (11). In select cases, a concomitant ipsilateral nephroureterectomy may be required should an atrophic kidney have an ectopic ureter draining into the seminal vesicle. It is recommended that the laparoscopic nephroureterectomy be performed prior to the seminal vesicle dissection. Thus, the patient would begin the procedure in a modified lateral decubitus position and then the operating table would be rotated so as to bring the patient into a relative supine and Trendelenburg direction. The operative details of laparoscopic nephrectomy for benign disease are described in Chapter 124.

Laparoscopic robotic assistance for surgery of the seminal vesicles has usually been performed in conjunction with radical prostatectomy. This technique, with respect to port placement and approach, is almost identical to the standard laparoscopic route described (12).

Laparoendoscopic single-site surgery (LESS) is another minimally invasive technique that has been used for many urologic procedures. Recently, Jang et al. (13) used this approach to excise a seminal vesicle cyst. For LESS, the patient is positioned similarly to laparoscopic/robotic approaches discussed earlier. A 3-cm skin incision is made at the umbilicus. A multichannel trocar with three 12-mm ports and one 5-mm port is inserted under direct visualization. Pneumoperitoneum is established. A rigid 30-degree, 10-mm laparoscope; articulating laparoscopic instruments, including a dissector, monopolar hook, scissors, and needle holder; and standard straight working instruments are used. Incision in the retrovesical peritoneum allows for seminal vesicle cyst visualization. Dissection of the vas from lateral to medial allows for full exposure of cyst. The seminal vesicle cyst is then drained by aspiration followed by circumferential dissection. After the base is exposed, LigaSure vessel sealing system (Valleylab, Boulder, Colorado) is used to seal the neck of the cyst. The peritoneum is sutured closed (13,14).

Although the transperitoneal laparoscopic/robotic approach to the seminal vesicles offers improved visualization to the seminal vesicles, the latter’s close proximity to bladder, rectum, ureter, and neurovascular bundle must be appreciated by the surgeon. Transperitoneal incision in the pouch of Douglas, which is too anterior, may lead to perforation of the posterior bladder wall. Subtle hints that the surgeon may be dissecting too anterior would be the appearance of the detrusor musculature, which is quite vascular and tends to bleed easily. Should a hole be made in the bladder, it can be repaired laparoscopically or robotically without undue difficulty.

Similarly, the rectal wall may be incised at any point in the seminal vesicle mobilization. Assuming the patient has received a satisfactory bowel preparation, such rectal lacerations may be laparoscopically or robotically repaired in two layers. The anal sphincter is dilated at the termination of the procedure and the patient’s diet is advanced slowly. Electrocautery must be used judiciously when in close proximity to the rectum. Use of precise bipolar coagulation is recommended.

The distal ureter runs close to the tip of the seminal vesicle. Any tubular structure that is lateral to the seminal vesicle may be the vas arching upward toward the internal ring, but it also could be the ureter. The surgeon may easily become disoriented to which ampulla of the vas is being dissected, leading to the dissection shifting too far lateral and possibly injuring or transecting the ureter. Injection of intravenous methylene blue quickly confirms the ureteral injury. Should this unfortunate complication occur, the ureter could possibly be repaired by laparoscopic or robotic suturing.

However, an ureterovesical reimplantation may be required and necessitate open surgical conversion. Placement of a double-J ureteral stent following repair is wise, and a pelvic drain is strongly advised in the presence of any bladder, rectal, or ureteral injury that may have occurred during the course of laparoscopic or robotic seminal vesicle dissection.

Finally, the neurovascular bundle is just lateral to the tips of the seminal vesicles. Injury to this structure will impair erectile function and create a serious problem, especially to the potent patient who may be undergoing seminal vesicle excision for benign disease.

Although data are limited for laparoscopic and robotic excision of benign seminal vesicle pathology alone, this approach appears to afford superb visualization with minimal postoperative morbidity and shorter hospitalization compared to the open surgical alternatives (5). In most cases, the seminal vesicle is excised laparoscopically or robotically in conjunction with radical prostatectomy or cystoprostatectomy.

Endoscopic Treatment

Transurethral Resection. If the cyst or abscess is adjacent to the prostate (not in the middle or distal end of the seminal vesicle), it may be possible to unroof the cavity with a deep transurethral resection into the prostatic substance, just distal to the bladder neck at the 5 or 7 o’clock position. However, urinary reflux, with resultant postvoid dribbling, and infection are potential complications (15). Previous reports have detailed endoscopic treatment of seminal vesicle abscesses using semirigid ureteroscopes as well as drainage of a seminal vesicle cyst cystoscopically with an incision using a Collins knife (1).

Outcomes

Results

Resection of the seminal vesicles for cystic and inflammatory diseases is in general successful, although large case series are rare. Seminal vesicle extirpation for cancer has also been successful, but the rarity of this indication prohibits an accurate assessment of survival and cure rates. Strict categorization of the 100 reported cases of primary seminal vesicle cancer reveals that fewer than 50% are truly primary to the seminal vesicle (16).

Complications

Each approach to seminal vesicle surgery is associated with unique complications. The relative complication rates with these approaches are outlined in Table 50.1. Limited extraperitoneal rectal injuries can be handled with formal two-layer closure. Rectal injury with the retrovesical approach is intra-abdominal, however, and may require the placement of omentum over the repair or even temporary colostomy. Most bladder injuries can be closed primarily. The most important point about ureteral injuries is their recognition. Most ureteral injuries can be treated adequately with stents for 7 to 10 days.

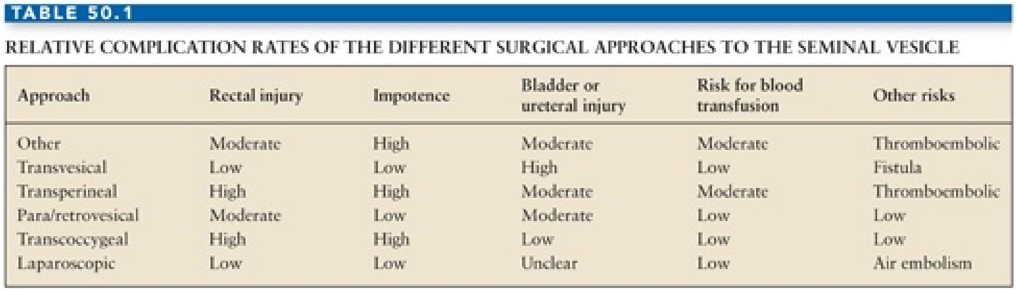

TABLE 50.1

RELATIVE COMPLICATION RATES OF THE DIFFERENT SURGICAL APPROACHES TO THE SEMINAL VESICLE

Approach	Rectal injury	Impotence	Bladder or ureteral injury	Risk for blood transfusion	Other risks
Other	Moderate	High	Moderate	Moderate	Thromboembolic
Transvesical	Low	Low	High	Low	Fistula
Transperineal	High	High	Moderate	Moderate	Thromboembolic
Para/retrovesical	Moderate	Low	Moderate	Low	Low
Transcoccygeal	High	High	Low	Low	Low
Laparoscopic	Low	Low	Unclear	Low	Air embolism

EJACULATORY DUCT SURGERY

The ejaculatory ducts are paired, collagenous, tubular structures that commence at the junction of the vas deferens and seminal vesicle, course through the prostate, and empty into the prostatic urethra at the verumontanum. There are three distinct anatomic regions to the ejaculatory duct: the proximal and largely extraprostatic portion, the middle intraprostatic segment, and a distal segment that is incorporated into the lateral aspect of the verumontanum in the prostatic urethra (17).

The duct consists of three histologic layers: an outer muscular layer, a collagenous middle layer, and an inner mucosal layer (18). The muscular layer is absent in the distal segment.

Indications for Surgery

Patients with ejaculatory duct obstruction sufficient to cause coital discomfort, recurrent hematospermia, or infertility should be considered candidates for transurethral treatment. Infertility with duct obstruction can present with low ejaculate volume and azoospermia or low ejaculate volume with decreased sperm density ($<20 \times 10^6$ sperm per Ml) or impaired sperm motility (<30% motility). Anatomic findings suggestive of obstruction and lesions located within approximately 1 to 1.5 cm of the verumontanum are usually amenable to transurethral management.

Diagnosis

Ejaculatory duct obstruction causes infertility in 5% of azoospermia cases. Duct obstruction can result from seminal vesicle calculi, müllerian duct (utricular) or wolffian duct (diverticular) cysts, postsurgical or postinflammatory scar tissue, calcification near the verumontanum, or congenital atresia (15). Classically, this condition presents as hematospermia, painful ejaculation, or infertility with azoospermia. Associated risk factors include evidence of prior urinary tract infection or trauma and perineal pain or discomfort. It is important to discontinue medications that may impair ejaculation. An abbreviated list of these medications is found in Table 50.2. Ejaculatory duct obstruction is suggested by finding enlarged, palpable seminal vesicles on rectal examination. The diagnosis is confirmed by a combination of findings:

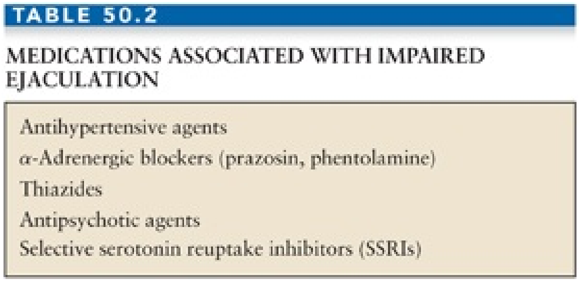

TABLE 50.2

MEDICATIONS ASSOCIATED WITH IMPAIRED EJACULATION

Antihypertensive agents
α-Adrenergic blockers (prazosin, phentolamine)
Thiazides
Antipsychotic agents
Selective serotonin reuptake inhibitors (SSRIs)

1. An ejaculate volume <1.0 mL and a pH <7.0 that contains no sperm or fructose (in the presence of palpable vas deferens)
2. A TRUS demonstration of dilated seminal vesicles (>1.5 cm in width) or dilated ejaculatory ducts (>2.3 mm) in association with a cyst, calcification, or stones along the duct

Recently, high-resolution TRUS has virtually replaced the more invasive vasography for this diagnosis. MRI with endorectal coil is recommended in suspicious cases without TRUS findings as it is excellent for the detection of small cysts. To complete the evaluation for infertility, it is important that the serum follicle-stimulating hormone (FSH) and testosterone levels be normal. Testicular volume should also be normal. A testis biopsy confirming ongoing sperm production may be helpful but is not always necessary.

Not all patients with ejaculatory duct obstruction have dilated seminal vesicles, and not all patients with dilated seminal vesicles have ejaculatory duct obstruction. This has led to refinements in diagnostic techniques. Jarow (17) found that seminal vesicle sperm aspiration with TRUS more accurately defined affected patients. Additionally, Engin et al. (19) reported that 55 (78.6%) patients had findings consistent with ejaculatory duct obstruction on diagnostic TRUS. However, obstruction confirmed by presence of sperm on aspiration was only found in 49.1% (27 of 55) of the patients, emphasizing that TRUS alone is not a reliable tool to diagnose ejaculatory duct obstruction (19). With a 30-cm, 21-gauge needle (Williams, Chiba, or oocyte retrieval needle), the seminal vesicles are aspirated transrectally or transperineally during TRUS (Fig. 50.6A). The aspirate is then examined under 400× phase microscopy for sperm. The finding of more than three sperm per high-power field is considered positive and suggestive of obstruction. Importantly, the duration of sexual abstinence prior to aspiration can influence the findings. Seminal vesicle aspiration should be performed with <24 hours of sexual abstinence. Despite the fact that aspiration does not anatomically localize the site of blockage or differentiate between physical blockage and functional obstruction, it confirms that spermatogenesis is ongoing and that epididymal obstruction is unlikely.

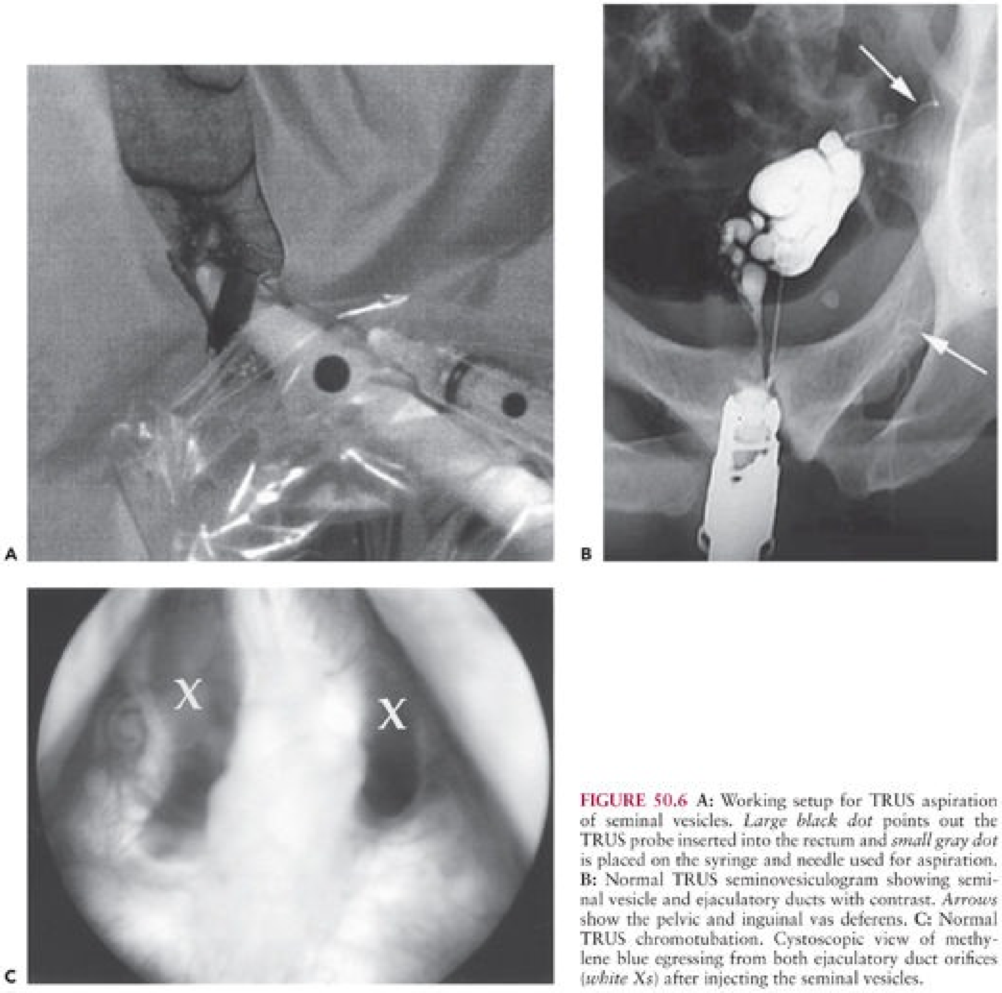

FIGURE 50.6 A: Working setup for TRUS aspiration of seminal vesicles. *Large black dot* points out the TRUS probe inserted into the rectum and *small gray dot* is placed on the syringe and needle used for aspiration. B: Normal TRUS seminovesiculogram showing seminal vesicle and ejaculatory ducts with contrast. *Arrows* show the pelvic and inguinal vas deferens. C: Normal TRUS chromotubation. Cystoscopic view of methylene blue egressing from both ejaculatory duct orifices (*white Xs*) after injecting the seminal vesicles.

Injection of nonionic contrast (50% Renografin) into the seminal vesicles after seminal vesicle aspiration, followed by formal radiographic imaging, can be a useful retrograde study of seminal vesicle and vasal anatomy in suspected obstruction (Fig. 50.6B). Also, a good-quality pelvic and inguinal vasogram can be obtained in most patients (see Fig. 50.6B). Fluoroscopy or a kidney-ureter-bladder (KUB) plain film is taken after the injection of 5, 10, and 20 mL of contrast to delineate excurrent duct anatomy. Helpful maneuvers include (a) having the patient in the 15- to 30-degree reverse Trendelenburg position for radiographs to “open up” the pelvic outlet and minimize overlying pelvic bone density and (b) placing a Foley catheter with 5 mL of water in the balloon on slight traction during contrast injection to reduce the spillage of contrast into the bladder that “clouds” the radiograph. As seminal vesiculography is more invasive than simple aspiration, it may require mild intravenous sedation and is best performed at the time of transurethral surgery.

Injection of diluted indigo carmine or methylene blue (1:5 dilution with saline) into the seminal vesicle with TRUS instead of contrast is termed *seminal vesicle chromotubation*. When performed with cystoscopy, it can assess whether or not there is antegrade flow of dye from the seminal vesicle into the prostatic urethra (Fig. 50.6C). In fact, “patency,” with chromotubation, defined by the presence of dye egressing from the ejaculatory duct orifices after seminal vesicle injection, may be the most accurate way to diagnose complete ejaculatory duct obstruction, unilateral, or bilateral (20).

Surgical Technique

Transurethral resection of the ejaculatory ducts (TURED) is performed in the outpatient setting. Following the administration of light general or regional anesthesia and a single dose of a broad-spectrum antibiotic, the patient is placed in the dorsal lithotomy position with a rectal drape

(O’Connor). Formal cystourethroscopy is performed. Careful examination is made of the areas lateral to the verumontanum within the prostatic urethra to visualize either ejaculatory duct orifice. A small resectoscope (24Fr) and electrocautery loop are inserted and the verumontanum is resected in the midline (Fig. 50.7). The resection is performed with pure cutting current to minimize cauterization of the delicate ejaculatory ducts. Often, several passes of the cutting loop are required to visualize the ejaculatory duct openings within the prostate. This can mean relatively deep dissection in a small prostate gland, a situation that can make even an experienced transurethral surgeon feel uneasy. At the correct level of resection, cloudy, milky fluid can usually be seen effluxing from the opened ducts. After resection, large bleeding blood vessels are lightly cauterized, with care taken to avoid fulguration of the duct openings. Because the area of resection is at the prostatic apex, near both the external urethral sphincter and the rectum, careful and constant positioning of the resectoscope is essential. A finger placed in the rectum can help avoid rectal injuries and assist in keeping the resectoscope tip proximal to the external sphincter. A small Foley catheter is placed for 24 to 48 hours and removed on an outpatient basis. Oral antibiotics are given while the catheter is in place. After such treatment for infertility, intercourse is resumed after 7 days, and a formal semen analysis is checked as early as 2 weeks and then at regular intervals thereafter, until semen quality stabilizes.

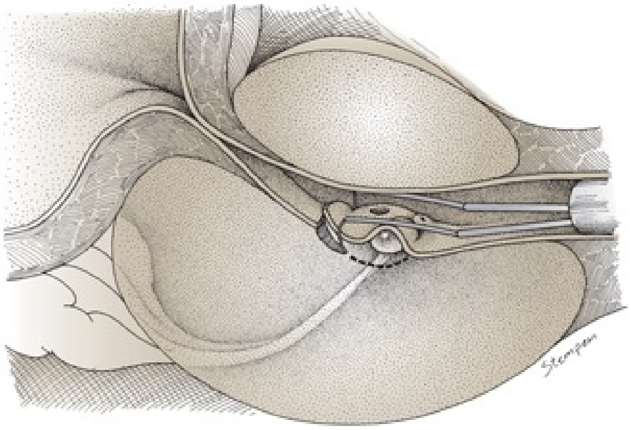

FIGURE 50.7 Transurethral resection for ejaculatory duct obstruction. Midline resection of the verumontanum is shown. Lateral and deeper resection may be necessary depending on the site and reason for duct obstruction. (Conceptualized by Paul Stempen.)

Several useful aids can ensure that the resection is performed safely and completely. With an endoscopic needle, the milky ejaculatory duct fluid can be sampled transurethrally during the procedure and inspected with microscopy for sperm. The use of simultaneous, real-time TRUS during the resection is a valuable addition to this procedure. The exact location of the lesion to be resected can be determined by TRUS and the depth of resection continuously assessed during the resection. Similarly, TRUS can be used to guide the instillation of indigo carmine or methylene blue into the seminal vesicles with a long, 20-gauge Chiba needle before the resection. The dye is subsequently visualized on relief of obstruction.

More recently, transurethral endoscopy and vesiculoscopy have been used to both diagnose and treat hematospermia and ejaculatory duct obstruction. This procedure is completed by passing a 6Fr or 7Fr ureteroscope retrograde through the orifice of the verumontanum over a 0.032 guidewire. The ejaculatory duct orifices are then visualized and the membrane covering the orifices is punctured with a guidewire. The ureteroscope is passed into the seminal vesicles. After this procedure, levofloxacin wash is directly injected into the seminal vesicles, and a Foley catheter is left for 24 hours (21,22).

Results

Long-term relief of postcoital and perineal pain after TURED can be expected in 60% of patients (22). Hematospermia has also been effectively treated with TURED, but the literature on this indication remains anecdotal. There is convincing evidence from several large series of patients treated for infertility that a 20% to 30% pregnancy rate can be expected from TURED (23,24). In one series, men treated for either low-volume azoospermia or low-volume oligoasthenospermia were equally likely (65% to 70%) to show improvements in semen quality after TURED (24). However, it appears that partial versus complete obstruction shows better improvement in semen parameters (100% versus 23.5%) (25). In one series, obstruction due to cysts responds better to TURED than that due to calcification (26).

Several caveats of TURED surgery should be emphasized to the patient preoperatively. Roughly, 13% of men treated by TURED for low-volume azoospermia will convert to normal-volume azoospermia. Among these patients, some have evidence of secondary obstruction at the level of the epididymis that requires epididymovasostomy. Epididymal obstruction may reflect the effects of time and blockage on other portions of the delicate male ductal system. Notably, 4% of patients treated for low-volume oligoasthenospermia may become azoospermic after TURED, presumably from scar tissue formation. We now recommend preoperative sperm cryopreservation if TURED is planned for this indication.

Regarding endoscopic therapy, there are limited studies. Liu et al. (20) studied 72 patients who underwent transurethral seminal vesiculoscopy for hematospermia. Symptomatic improvement occurred in 97% of these men. Furthermore, Wang and colleagues (21) completed seminal vesiculoscopy using a 6Fr endoscope in 21 patients with erectile dysfunction and infertility. Sperm was found in the ejaculate in 85% of patients. However, pregnancy rates were not reported. There were no intraoperative complications associated with this procedure (21,22).

Complications

The expected complication rate from TURED surgery is approximately 20% (15). The most common complications are self-limited hematospermia, hematuria requiring recatheterization, and urinary tract infection. More concerning, but less frequent, are epididymitis and a “watery” ejaculate. High-volume watery ejaculate is presumed secondary to the reflux of urine retrograde through the ejaculatory ducts into the seminal vesicles or into opened cysts, as suggested by the finding of creatinine in the ejaculates of TURED patients. In addition to the social implications of this, the exposure of sperm to urine may impair fertility potential. Several potentially major but rarely reported complications include retrograde ejaculation, rectal perforation, urinary incontinence, and recurrent seminal vesicle infection.

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CHAPTER 51 VASECTOMY

DOUGLAS G. STEIN

As the most dependable method of contraception and one that requires virtually no compliance, vasectomy is an ideal choice for those men who have made a mature, informed decision to have no more children, and especially for men who have difficulty with compliance. As a result, 12% of the U.S. population relies on vasectomy as their primary method of birth control. National surveys of vasectomy providers indicate an incidence of vasectomy of 500,000 per year in the United States, but patient-based surveys would indicate an incidence of 175,000 to 300,000 (1). While it has been noted that vasectomy is the "most common procedure involved in malpractice claims against urologists" (2), vasectomy accounted for only 8 of 469 (1.7%) urology malpractice claims closed with indemnity payment between 1985 and 2004 (3). So, while urologists need not avoid vasectomy to decrease perceived high liability, they need to be thoroughly versed in the management of men seeking vasectomy. Vasectomy Guidelines were published by the American Urological Association (AUA) in 2012. From ~2,000 titles and abstracts, the AUA Guidelines Committee reviewed 900 articles and selected 275 to formulate 15 guidelines, which will be incorporated into this chapter. These guidelines with full explanations and references are available on the website of the AUA at http://www.auanet.org/education/guidelines/vasectomy.cfm.

DIAGNOSIS

The consultation visit should accomplish two objectives: (a) The patient should learn all aspects of vasectomy that constitute informed consent, including pre- and postvasectomy instructions, the benefits, the risks, and the alternatives, and (b) the doctor should assess the patient's social and medical histories and his genital anatomy to determine whether he is a good candidate for vasectomy and advise him accordingly. According to the AUA Guideline Statement 1 (expert opinion), this process may take place in person or through an electronic and telephone exchange of information, values, and opinions.

In-person consultations allow the vasectomist to examine the patient to determine whether there are features of the patient's anatomy or personality, which either (a) make him a better candidate for general anesthesia than for the more commonly used local anesthesia with or without oral or intravenous sedation, or (b) warrant referral to a more experienced vasectomy provider if general anesthesia is not desired or practical. Such features include incomplete testicular descent (either untreated or status post orchiopexy); scarring due to prior scrotal surgery; a small tight scrotum; obesity with thick spermatic cords; very thin vasa; large hydrocele, spermatocele, or varicocele; or extreme scrotal hypersensitivity. Guidelines Statement 2 (expert opinion) lists 11 "minimum and necessary concepts" which should be conveyed, whereas Guidelines Statement 3 (standard) indicates that there is no need to discuss those conditions once considered risks of vasectomy that have been proven to have no connection with vasectomy. This author prefers an electronic exchange of information via his website, in which the patient and his partner can read about vasectomy and watch a counseling video at their own pace, at a convenient time, and as often as they would find necessary to achieve full understanding. Patients preregister to provide the physician's office with (a) relevant medical and social information, which can be considered long in advance of the procedure, and (b) acknowledgment of understanding of all aspects of vasectomy including preparation and postoperative recommendations. Patients and doctor can opt for an in-person consultation if warranted by elements of the patient's history; for example, a history of prior orchidopexy, vasectomy/reversal, or obesity. Young men (<30 years) with fewer than two children are interviewed by phone to determine their motives, to explain reversible alternatives, and to confirm full understanding of the long-term implications of vasectomy. They are encouraged to consider sperm storage. Men who have never caused a pregnancy are asked to return a specimen mailer before the vasectomy to rule out azoospermia (avoid an unnecessary vasectomy) and to know about oligospermia, if present, in the event that they ever consider vasectomy reversal. The last 143 such cases included 4 with azoospermia and 6 with severe oligospermia (<25 sperm per high-power field [HPF]). The latter were offered formal semen analysis to establish a baseline.

The AUA Guidelines Committee includes the usual risks in the "minimum and necessary concepts" to be considered in the consultation exchange, namely, bleeding, infection, failure, and chronic pain. The guidelines also recommend that patients be "reassured" that there is no evidence of a cause-and-effect relationship between vasectomy and a change in sexual function. But through two large surveys of more than 100 respondents each, this author has learned that a small percentage of patients blame vasectomy for a diminution of libido, erectile function, or climax intensity. So this author includes those possibilities in his informed consent to avoid future legal problems.

INDICATIONS FOR SURGERY

While no strict criteria exist for determining which patient should be offered vasectomy, the Electronic Code of Federal Regulations for sterilization of persons in federally assisted family planning projects (Title 42 CFR Part 50 subpart B) specifies that the individual be at least 21 years of age and mentally competent when consent is obtained and that 30 days pass between the date of consent and the date of vasectomy.

ALTERNATIVE THERAPY

Especially because vasectomy should always be presented as a permanent form of contraception, a full disclosure of alternative contraceptive methods must be a part of informed consent. While condoms are the only other alternative available to males, men should have a thorough understanding of the options available to women, even though these provide less control for the male. When features of the male anatomy (obesity, tight scrotum, thin vasa, or scarring from prior scrotal surgery) would make vasectomy difficult for the vasectomist at his or her skill level, couples considering permanent contraception should be asked to consult with a more experienced vasectomist, as complications rates are lower for vasectomies performed by more experienced vasectomists (4). Although not guaranteed successful, patients should be counseled regarding sperm cryopreservation and storage as an insurance policy that may enable paternity after vasectomy without need for vasectomy reversal.

SURGICAL TECHNIQUE

Nearly all surgical procedures involve three steps: (a) anesthesia, to allow the procedure to proceed without pain, (b) access, or how the surgeon gets to the target organ, and (c) technique, how one manages the target organ, the actual occlusion of the vas deferens. Except for patients with comorbidities associated with a high risk of infection (e.g., diabetes, immunodeficiency, coexistent infection), the AUA Guideline Statement 4 recommends no preoperative antibiotics.

Anesthesia

AUA Guideline Statement 5 is an expert opinion that “vasectomy should be performed with local anesthesia with or without oral sedation . . . if the surgeon believes that local anesthesia with or without oral sedation will not be adequate for a particular patient, then vasectomy may be performed with intravenous sedation or general anesthesia.”

Despite the growing popularity of no-needle anesthesia since 2002 (5), especially appealing to men who “just hate needles,” administration of *anesthesia with a needle* is the most common and traditional technique, with a 2010 article (6) promoting a “mini-needle” technique. Using a three-finger no-scalpel vasectomy (NSV) technique to hold the vas beneath the median raphe, a 1-inch 30-gauge needle and 3 mL syringe are used to deliver 0.5 mL of 2% lidocaine to create a midline skin wheal through which an additional 0.50 to 0.75 mL is injected as close as possible and even into each vas in turn (Fig. 51.1). Vasectomy is started immediately on the first side injected.

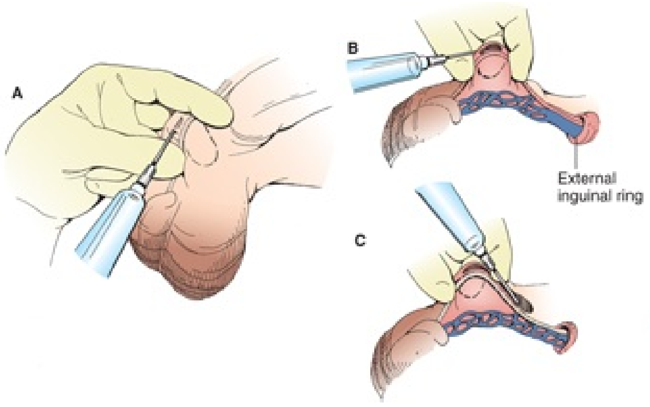

FIGURE 51.1 A and B: The vas deferens is lifted into position beneath the midline and anesthetic injected into the skin directly over it. C: Through the anesthetized skin, anesthetic is injected directly alongside the vas.

No-needle local anesthesia for vasectomy involves the use of a jet injector (or “spray applicator,” as this surgeon prefers to call it), the most popular of which is the MadaJet (MADA, Inc, Carlstadt, New Jersey). The spring-loaded MadaJet (Fig. 51.2) emits an extremely thin 0.1 to 0.2 mL stream of anesthetic (2% lidocaine, 0.5% bupivacaine or a mixture, depending on the duration of anesthesia desired) strong enough to penetrate the skin and underlying tissue to a depth of 2 to 5 mm, depending on the factory setting of the particular MadaJet. The vas is lifted into position beneath the skin at the preferred access site (anterior midline for NSV or lateral scrotal wall for traditional approach), the overlying skin is prepped with alcohol, the fluted spacer of the MadaJet is pressed over the vas (Fig. 51.3), and the release button is pressed to discharge the anesthetic through the skin and around the vas. The procedure may be repeated along the path of the vas at a 4- to 5-mm interval, but one application per vas is often adequate. Medication entry sites are barely visible as minute dots, surrounding which are 6- to 10-mm diameter areas of anesthetized skin. If the *right* vas is lifted to the midline and injected 2 mm to the *left* of the median raphe, and if the left vas is then lifted to the midline and injected 2 mm to the right of the median raphe, the patient develops an area of anesthetized skin about 5 mm on each side centered on the midline, and the scrotal septum receives all doses of the anesthetic. Through the anesthetized area, a minimally invasive vasectomy (MIV) is performed. (If anesthesia of the skin or vas is not adequate to perform a vasectomy without pain, supplemental anesthesia with a needle can be applied.) Because only the spacer touches the patient, it can be soaked in an antibacterial/antiviral antiseptic solution between cases, or a freshly autoclaved spacer can be used for each case.

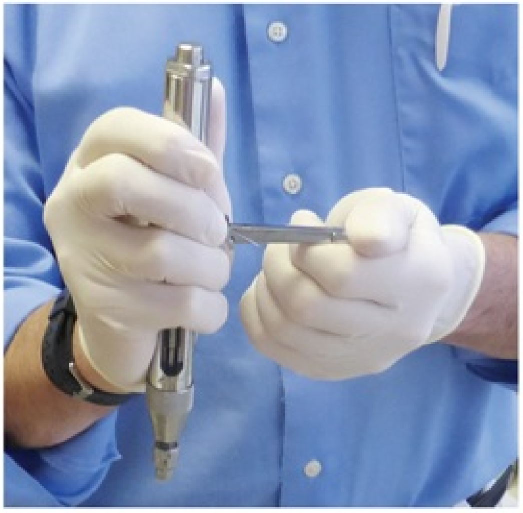

FIGURE 51.2 Cocking the MadaJet: The lever is depressed until the release button at the top pops up.

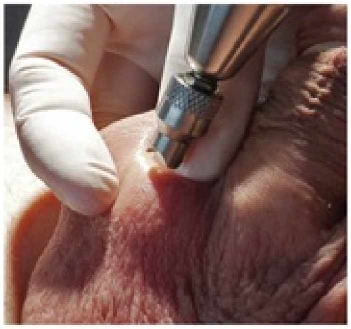

FIGURE 51.3 Fluted tip of MadaJet being lowered onto the right vas, held beneath the median raphe with a three-finger technique.

Access

AUA Guideline Statement 6 states that an MIV technique (skin opening <10 mm and minimal dissection of the vas and perivasal tissues) should be used. Because this is a standard based on grade B evidence, the conventional vasectomy will not be described here. The guidelines specify that the classic Li NSV technique is one form of MIV. Any deviation from nine steps in the description of the Li NSV technique warrants that the method be described as an MIV. As long as the access technique, whether performed on the lateral scrotal walls or in the midline, uses a skin opening <10 mm and minimal dissection of the vas and perivasal tissues (with the Li NSV vas dissector and ring clamp or similar instruments), it can be considered an MIV.

The Li NSV technique (7) uses the vas dissector and ring clamp and a three-finger technique (Fig. 51.4) to access both vasa in turn via a single small opening in the anterior midline of the scrotal wall (anesthetized with needle- or spray-applicator-applied lidocaine). After the scrotum is formally prepped with povidone-iodine or chlorhexidine/alcohol and draped, needle anesthesia is used (see previously) or the pinpoint marks in the skin made by the spray applicator are located. In the Li technique, the vas, most commonly located on the posterior aspect of the spermatic cord, is swept medially and lifted into position beneath the median raphe (the site already anesthetized if the spray applicator was used) using a three-finger technique. The vas and overlying skin are grasped with the ring clamp (Fig. 51.5A), its tips applied at the left and right MadaJet application sites. If this is difficult, because the skin is thick or the vas thin, the surgeon may find it easier to puncture and spread the skin with the vas dissector then grasp the vas with the ring clamp through the opening thus created (Fig. 51.5B), still an MIV, but no longer a Li NSV, strictly speaking. MadaJet injection application sites can be difficult to locate, especially in dark-skinned men, so this step and the remainder of the vasectomy may be much easier with the magnification provided by 2.5× optical loupes. One tip of the vas dissector is introduced into the lumen of the vas and removed (Fig. 51.6). Both tips are introduced at the same spot and spread to twice the width of the vas (Fig. 51.7), splitting the vas open longitudinally and spreading all overlying layers. One tip of the vas dissector is then used to “hook” the vas (Fig. 51.8) and lift it from its sheath as the ring clamp is removed. The ring clamp is then used to grasp one wall of the vas and deliver a 1- to 2-cm loop of it from its sheath (Fig. 51.9).

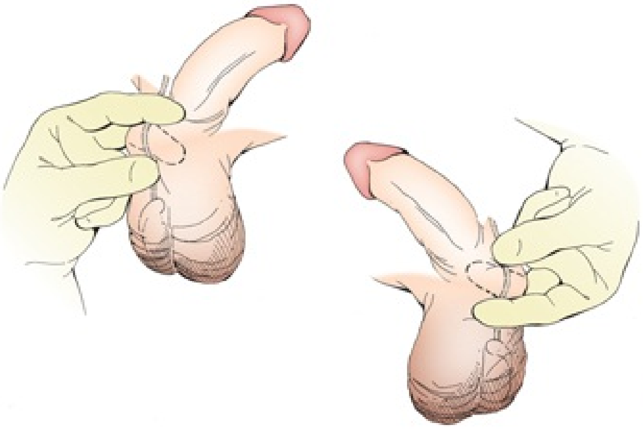

FIGURE 51.4 The three-finger technique for isolating the (**A**) right and (**B**) left vas deferens.

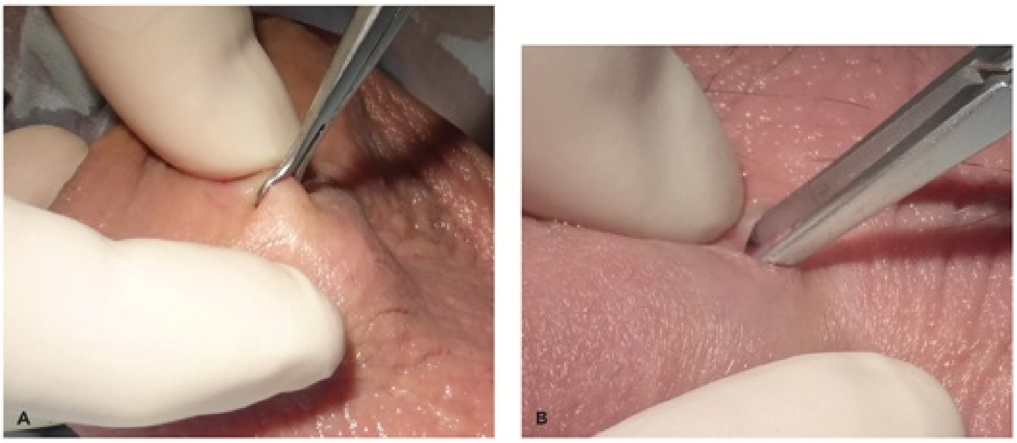

FIGURE 51.5 **A:** Held using the three-finger technique, the right vas is grasped with the NSV ring clamp, incorporating the skin. **B:** In some cases (e.g., thick skin or thin vas), it may be easier to grasp the vas through a skin opening made with the NSV dissecting clamp.

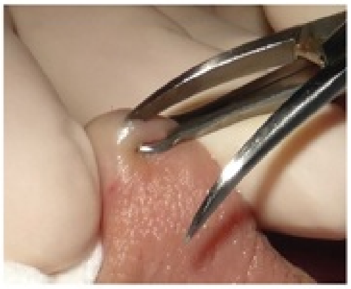

FIGURE 51.6 One tip of the NSV dissecting clamp is introduced into the lumen of the vas.

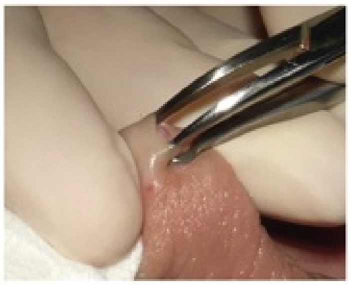

FIGURE 51.7 Then both tips are introduced, and all layers are spread to twice the diameter of the vas.

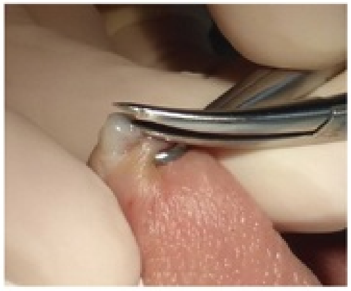

FIGURE 51.8 The split vas is hooked with the dissecting clamp and delivered while the ring clamp is released.

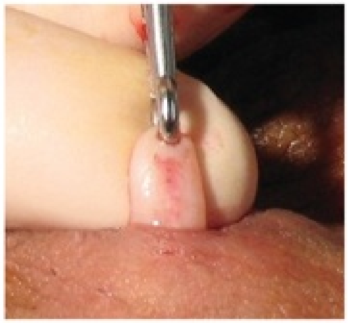

FIGURE 51.9 A loop of vas is delivered and grasped with the ring clamp, its mesentery still intact.

Occlusion

Numerous methods for obstructing the vas have been described, and most surgeons employ a combination of luminal cauterization, ligation, division, excision, and fascial interposition with either a suture ligature or hemoclip (8) (Figs. 51.10 to 51.13). The objective should be very low failure and low complication rates, without removing so much vas, especially in young patients, that vasectomy reversal is rendered extremely difficult. “Early” failure is said to occur when the postvasectomy patient has motile sperm or significant numbers (>100,000 per mL) of nonmotile in the semen 6 months after vasectomy. Recanalization within the tissue between the two severed ends occurs frequently during the 1 to 2 months following vasectomy but usually scars off (9). Early failure occurs when recanalization does not scar off but rather persists. “Late” failure is the return of motile sperm to the semen of a patient previously diagnosed as azoospermic, an event caused by delayed recanalization and usually discovered as a result of a surprise pregnancy.

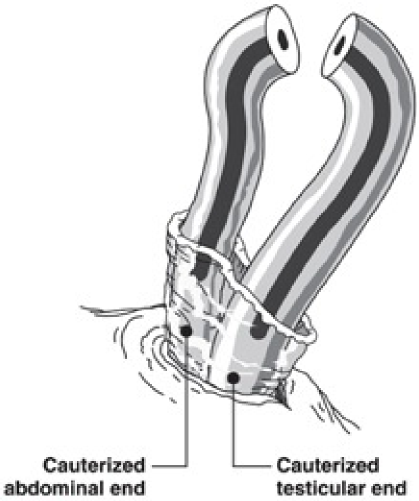

FIGURE 51.10 Cauterization of both ends without excision of a segment or fascial interposition. (Copyright and courtesy of Barone MA, Irsula B, Chen-Mok M, et al; Investigator Study Group. Effectiveness of vasectomy using cautery. *BMC Urol* 2004;4:10, http://www.biomedcentral.com/1471-2490/4/10.)

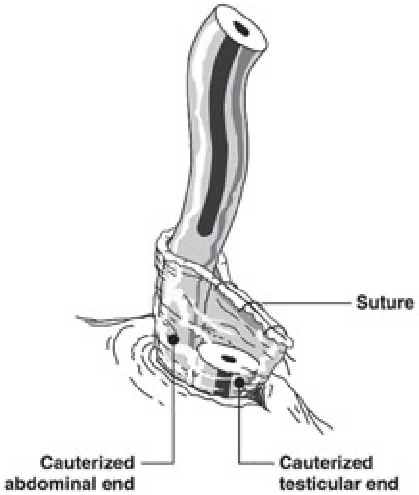

FIGURE 51.11 Cauterization of both ends with fascial interposition over the testicular end (abdominal end left outside sheath) using suture. (Copyright and courtesy of Barone MA, Irsula B, Chen-Mok M, et al; Investigator Study Group. Effectiveness of vasectomy using cautery. BMC Urol 2004;4:10, http://www.biomedcentral.com/1471-2490/4/10.)

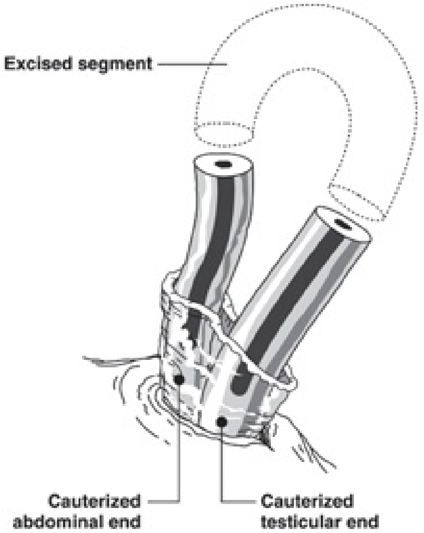

FIGURE 51.12 Cauterization of both ends with excision of a segment but no fascial interposition. (Copyright and courtesy of Barone MA, Irsula B, Chen-Mok M, et al; Investigator Study Group. Effectiveness of vasectomy using cautery. BMC Urol 2004;4:10, http://www.biomedcentral.com/1471-2490/4/10.)

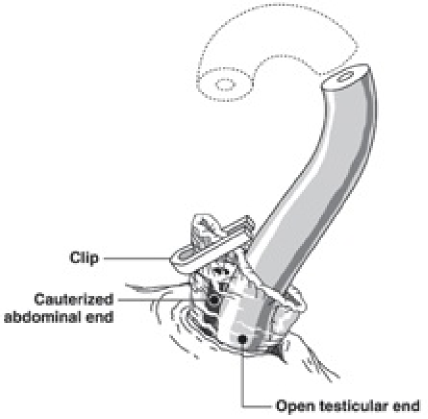

FIGURE 51.13 Cauterization of the abdominal end only (open-ended technique) with fascial interposition over the abdominal end (testicular end left outside sheath) using a hemoclips. (Copyright and courtesy of Barone MA, Irsula B, Chen-Mok M, et al; Investigator Study Group. Effectiveness of vasectomy using cautery. *BMC Urol* 2004;4:10, http://www.biomedcentral.com/1471-2490/4/10.)

There are numerous reviews of surgical techniques (8–10), and the AUA Guidelines Committee performed an exhaustive review of a total of 89 study arms worthy of inclusion, for a total of 126,821 patients. Techniques worthy of recommendation were those for which a fair number of studies (>3) with an adequate number of total patients (>1,000) all reported failure rates of less than 1%. (Other techniques were represented by studies that showed widely varying success rates or by studies that provided insufficient evidence of efficacy [e.g., only one study.]) One notable exception was nondivisional electrocautery technique of the Marie Stopes organization: only a single study but 41,814 patients across many centers and many clinicians with consistently low failure rates of 0.28% to 1.3%. Labrecque and Caron (11) were unable to duplicate this success rate with 1 cm of thermal mucosal cautery proximal and distal to a 0.5-cm segment of vas from which the anterior wall and mucosa had been completely removed/destroyed by thermal cautery, and they discontinued the study when preliminary results showed a failure rate of 14.8%. They surmised that the Marie Stopes electrocautery technique was more destructive (90% of the vas wall thickness as opposed to mucosa only) over a longer distance (3 cm as opposed to 2.5 cm). When a segment is not excised or fascial interposition used, the addition of division did not reduce the failure rate in a study of the effectiveness of various cautery techniques (9).

So, AUA Guideline Statement 7 is a “recommendation” (not a standard) that occlusion be accomplished by (a) division followed by (i) intraluminal mucosal cautery (MC) of both ends and fascial interposition, (ii) MC of both ends without fascial interposition, or (iii) MC of the abdominal end with fascial interposition; or (b) the Marie Stopes nondivisional method (not recommended by the author).

However, given the large numbers of surgeons who use ligatures or clips and the presence of some studies which show acceptably low failure rates with these techniques, the AUA Guideline Committee provided AUA Guideline Statement 8 as an “option” that the vas may be divided and the ends occluded by ligatures or clips by surgeons who consistently obtain satisfactory results with such methods.

Routine histologic examination of the excised vas segments is not required (AUA Guideline Statement 9, expert opinion).

Ligation without division has a high early failure rate, even when employing a specially designed clip rather than a suture ligature or hemoclip (12). A newly designed ligation clip is still marketed, but there are not enough studies with enough patients showing failure rates of <1% to recommend it at this time.

Early recanalization and failure rates are highest for ligation and excision without fascial interposition and lowest for thermal cautery with fascial interposition (6,9). This is the rationale for the following technique.

Preferred Anesthesia, Access, and Occlusion Technique

The no-needle minimally invasive (sometimes “no-scalpel” by the strictest definition) vasectomy with thermal cauterization and hemoclip fascial interposition is performed as follows.

An elastic lasso is applied at the coronal sulcus and an attached hemostat is snapped onto the shirt to keep the penis elevated. Most patients, coached by online instructions and telephone staff, shave the night before so that the skin is not so sensitive to the alcohol used to prep it for application of the no-needle anesthesia. If needed, the anterior scrotal wall is shaved with a single-edge shaver. No-needle local anesthesia is applied to each vas in turn at a midline location as described previously. The scrotum is then formally prepped with a mixture of 4% chlorhexidine, alcohol, and water (1:1:2) and draped with a fenestrated 18 inch × 24 inch drape. If no-needle anesthesia is not used, needle anesthesia is applied as described previously.

After local anesthesia, the no-scalpel technique described previously is utilized to deliver a loop of vas from its sheath (see Fig. 51.9). It is important that the vas be opened a few millimeters lengthwise to confirm complete penetration of the sheath and to allow grasping of the vas wall with the ring clamp. The vas dissector is passed along the undersurface of the vas at the apex of the loop (Fig. 51.14). The dissector tips may be gently spread to push the adjoining vessels away from a 1- to 2-cm segment of vas (Fig. 51.15), but this may sometimes promote bleeding and is not always necessary. A small vasotomy opening is made in the prostatic end with one tip of the vas dissector or with the tip of a battery-powered wire loop thermocautery unit as though one were draining a subungual hematoma. The tip of the thermocautery unit is then introduced into the abdominal end and advanced 5 to 10 mm (Fig. 51.16). It is activated just long enough to sear the mucosal lining of the vas so that it will seal off by scarring. If applied too long, causing the full thickness of the wall to blanch, the cauterized segment may slough, negating the effectiveness of cautery in contributing to obstruction of the vas. Then the thermocautery unit or a scissors is used to divide the vas where the vasotomy was made. The abdominal end slips up into the vas sheath and the margins of the sheath are brought together and tented over the buried end with a Halsted hemostat or the NSV dissecting clamp (Fig. 51.17). At this point, the testicular end is still secured with the ringed clamp. The hemostat is now brought down to a position below the ringed clamp (toward the foot of the table) and transferred to the nondominant hand (Fig. 51.18). A gentle “tear back” of the testicular end assures that the posterior aspect of the vas sheath is included in the fascial closure. Small vessels may be included in the hemostat if necessary to optimize fascial interposition or to provide hemostasis. A medium hemoclip (or suture tie) is applied to the tissue in the hemostat alongside the testicular end of the vas, drawing the sheath around the testicular end so that it cannot slip back inside. When the hemostat is removed, the clip (or tie) rotates back cephalad and sits parallel to the testicular end (Fig. 51.19) so that it will not hang up on scrotal wall fascia as it released back into the scrotum. The sheath may appear to be drawn tightly around the lower end if it indents the surface, but it is unclear whether this compromises blood flow to the segment outside the sheath. If there is concern that the lower end may slough, leaving the remaining stump inside the sheath and defeating the intent of fascial interposition, a gentle spread of the tight band with the dissector will suffice. An additional hemoclip may be applied for hemostasis if necessary. The ringed clamp on the testicular end is opened and the divided vas ends fall back into the scrotum. The testicular end is not ligated or cauterized, making this an open-ended technique, which may provide some advantages (4). No segment is removed. If the surgeon prefers to remove a segment, AUA Guideline Statement 9 offers the expert opinion that histologic examination of the excised segment is not required. The same procedure is repeated on the other side through the same midline skin opening.

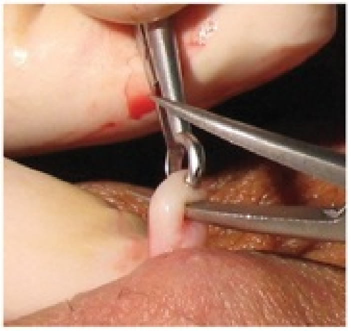

FIGURE 51.14 The NSV dissecting clamp is used to separate the vas from the underlying mesentery.

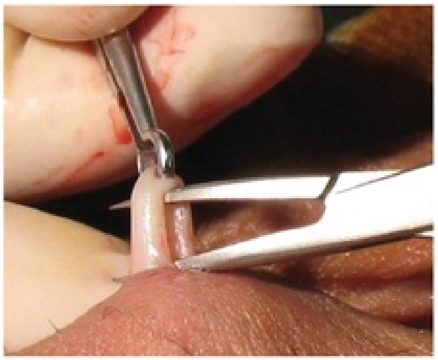

FIGURE 51.15 The NSV dissecting clamp may then be used to push back the mesentery and expose a longer loop of vas, but this sometimes causes bleeding and is not always necessary.

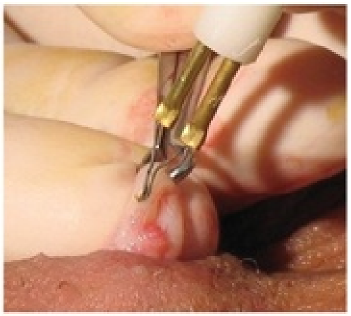

FIGURE 51.16 A thermocautery unit is introduced into the abdominal end only, if one prefers an "open-ended" vasectomy (testicular end not ligated or cauterized).

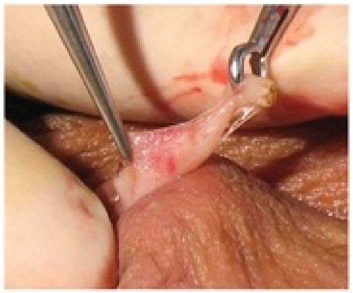

FIGURE 51.17 After the vas is divided with the thermocautery unit or with a scissors, the abdominal end slides into the vas sheath which is then closed over it with a Halsted hemostat or the NSV dissecting clamp.

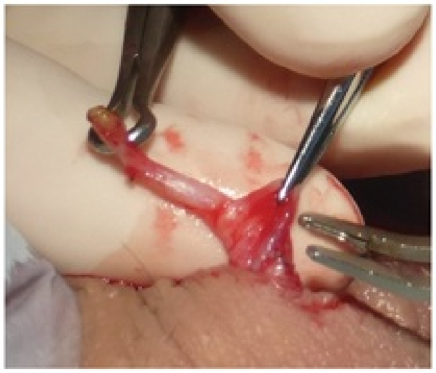

FIGURE 51.18 The closed sheath is rotated 180 degrees for easier application of a hemoclip while the testicular end is lifted to bring the underside of the vas into inclusion within the clip for more complete fascial interposition.

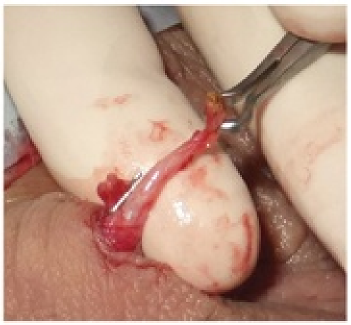

FIGURE 51.19 When the hemostat is removed, the hemoclipped sheath over the buried abdominal end rotates back to its original position, ready for return to the scrotum.

Tight underwear or an athletic supporter will hold a gauze pad in place and provide some comfort, or a Band-Aid can be used to cover the access site.

The patient is instructed to recline on the day of the surgery. Ice packs are recommended by some surgeons to decrease the risk of hematoma formation, but it is unclear whether the cold or the inactivity imposed by the ice pack provides the claimed benefit. On the day after surgery, patients may walk and drive ad lib but should avoid yard work, sports, and heavy lifting. They may shower, then continue use of scrotal supports for 2 more days. Two days after the vasectomy, patients may return to normal activities but refrain from ejaculation and limit aggressive athletic workouts until discomfort and tenderness have subsided.

Follow-up Semen Analysis

Postvasectomy semen analysis (PVSA) is used to confirm the effectiveness of a vasectomy postoperatively. AUA Guideline Statement 10 is the clinical principle that couples should use other contraceptive methods until success (effectiveness) is confirmed by PVSA. “Effectiveness” can be defined as either contraceptive effectiveness (absence of pregnancy) or occlusive effectiveness (ideally azoospermia). Some men fail to achieve azoospermia yet never cause a pregnancy, especially if their semen contains <100,000 nonmotile sperm per milliliter (“rare nonmotile sperm” or RNMS). The AUA Vasectomy Guidelines contain a long dissertation about the science of PVSA and emphasize the value of sperm motility as an indicator of vasectomy failure in those men with persistent seminal sperm 12 weeks after vasectomy. AUA Guideline Statement 11 offers the expert opinion that to evaluate sperm motility, a fresh semen sample should be evaluated within 2 hours after ejaculation.

If a *fresh* specimen contains fewer than 100,000 *nonmotile* sperm per milliliter (<1 sperm per three HPFs at 400× with many light microscopes), as will be the case for 95% at 12 weeks, no further testing is necessary, as 99.7% of these cases will achieve azoospermia or RNMS by 24 weeks (9) and the risk of pregnancy with fewer than 100,000 nonmotile sperm per milliliter is extremely low (13). So AUA Guideline Statement 12 is a recommendation that "patients may stop using other methods of contraception if one well-mixed, uncentrifuged, fresh post-vasectomy semen specimen shows azoospermia or only rare non-motile sperm (RNMS or <100,000 non-motile sperm per mL)."

Regarding the timing of the first semen evaluation, AUA Guideline Statement 13 (an option) states that "eight to sixteen weeks after vasectomy is the appropriate time range for the first PVSA. The choice of time to do the first PVSA should be left to the judgment of the surgeon." Ninety percent of men will achieve azoospermia or RNMS by 15 ejaculations (whichever comes first) after vasectomy.

In some cases, evaluation of a fresh semen sample is not logistically practical (patients who cannot get to a testing center within 2 hours and cannot produce a specimen at the center). If, at 12 weeks, a sample older than 2 hours (motility evaluation not reliable) shows azoospermia (an absolute value that may be a mathematical abstraction, but no sperm in 50 HPFs seems reasonable), the question of motility is moot. If any sperm are seen in 50 HPFs of a non-fresh specimen at 12 weeks, another container or mailer is provided. If any sperm are seen at 16 weeks in a second non-fresh specimen, evaluation of a fresh specimen is required despite logistical challenges. Labrecque et al. (13) propose a flow chart suggesting that testing be repeated every 4 to 6 weeks and that failure due to "persistent" recanalization (some cases will scar closed) be considered probable only if motile sperm persist beyond 6 months. When 100,000 or more nonmotile sperm per milliliter persist for over 6 months, failure should be considered, but even this is considered overly cautious by some (14,15). This data forms the basis of AUA Guideline Statement 14: "Vasectomy should be considered a failure if any motile sperm are seen on PVSA at six months after vasectomy," an expert opinion; and AUA Guideline Statement 15: "If >100,000 non-motile sperm/mL persist beyond six months after vasectomy, then trends of serial PVSAs and clinical judgment should be used to decide whether the vasectomy is a failure and whether repeat vasectomy should be considered," another expert opinion.

Compliance with PVSA (only about two-thirds of men return for at least one PVSA) may be enhanced by providing a specific appointment for the first PVSA. Home test kits are available (16), but improved compliance has not been studied or proven, and there is still insufficient data regarding the reliability of these kits in clinical practice.

When providing results, men should be reminded that vasectomy is *not* 100% *effective* even if azoospermia has been achieved because of the possibility of delayed recanalization, often detectable by simple semen analysis, unless the recanalization is transient, in which case DNA-documented paternity is possible even in the absence of detectable seminal sperm (17).

OUTCOMES

Results

Using fascial interposition with a hemoclip to bury the testicular end during the 16 years from 1990 through 2006, approximately 10,800 vasectomies were performed. An estimated 70% of men underwent postvasectomy semen testing. Of these 7,560, 4 patients (0.05%) experienced early failure (motile sperm at 4 months) and required repeat vasectomies, and 11 patients (of whom we are aware as of March 2014), or 0.1%, have experienced late failure: pregnancy and confirmation of motile seminal sperm or paternity more than 1 year after vasectomy (9 confirmed azoospermic after vasectomy and 2 not tested after vasectomy).

Starting in 2007, the author has buried the prostatic end of the vas, hoping for an even lower failure rate. From 2007 through 2013, 15,493 vasectomies were performed by the author with burial of the prostatic end, and 10,255 (66%) underwent postvasectomy semen testing. Of those tested, there have been six early failures (0.06%) (any motile sperm or >100,000 nonmotile sperm at >3 months, or a pregnancy sooner than 1 year in a man not tested after vasectomy). Of the entire group, there has been one late failure (0.0065%), but it is still too early to present a true rate of late failures (inadequate follow-up time) and to determine whether abdominal-end fascial interposition is superior to testicular-end fascial interposition.

Of interest is the fact that an associate trained by the author in the same technique had a higher failure rate in 911 cases over an 8-month period, of whom 659 patients (72%) underwent postvasectomy semen testing. There were six early failures (0.9%): five cases of motile sperm at >6 months and one case of >100,000 NMS at 10 months. This higher rate of early failure (over 10 times higher than that of the author) is evidence that subtle variations in even the same technique can result in different failure rates. It also makes a strong case for the need for every vasectomist to monitor his or her own rates of failure and modify his or her technique as needed to achieve an early failure rate of 1% or less.

Complications

Early

Three levels of hematoma are possible. Reported rates average about 2% but are higher (4.6%) for surgeons who perform few vasectomies (1 to 10 per year) and lower (1.6%) for surgeons who perform many vasectomies (>50 per year) (10). The incidence is lower with MIV (0.3% versus 1.4%) during which tissue is spread for exposure of the vas than with traditional vasectomy, during which tissue is cut for exposure of the vas (18).

Postvasectomy inflammation can occur anywhere from 3 days to years following vasectomy. Patients who have had little discomfort following vasectomy may “out of the blue” develop swelling and tenderness at the vasectomy site or within the epididymis and convoluted vas “upstream” from the vasectomy site. Most cases are unilateral and respond quickly to nonsteroidal anti-inflammatory drugs (NSAIDs).

Infection with conventional incisional vasectomy has been reported to occur in 1.4% of cases compared with a rate of 0.1% with NSV (18). In the absence of fever, it can be difficult to differentiate infection from common early postvasectomy inflammation, but infection should be considered in patients with swelling and tenderness that does not respond to NSAIDs. The most severe and obvious cases of infection develop into scrotal abscesses which require surgical drainage. There are two published reports of Fournier gangrene in healthy young men, with onset 1 to 2 days after vasectomy, both due to hemolytic strep, one case fatal (19,20).

Late

Sperm granulomas form at the vasectomy site to varying degrees in up to 60% of patients. A granuloma probably forms when sperm leak from the testicular end of the divided vas and incite the inflammation needed for their absorption, typically in the second or third week following vasectomy. This actually vents the congestion and inflammation that often occurs upstream in the proximal vas and epididymis and may enhance the prognosis for success with a future vasovasostomy. Open-ended vasectomy expectedly reduces the risk of pain due to congestive epididymitis but paradoxically does not increase the risk of tender sperm granuloma (21) and actually reduces it. For granulomas that are exquisitely tender, most patients will respond to nonsteroidal anti-inflammatories. Some may also respond to an injection of a steroid near the granuloma, but some will require surgical excision.

Chronic pain of the scrotal contents after vasectomy is a syndrome with various names: postvasectomy pain syndrome (PVPS), congestive epididymitis, postvasectomy orchialgia, and chronic testicular pain (22). In two studies conducted 7 to 12 months following vasectomy, 14.7% of men described some degree of chronic discomfort of the scrotal contents, approximately 1% described the pain as “quite severe and noticeably affecting quality of life” (23), and 1% to 2% expressed regret over having had the vasectomy because of pain. Rates were about the same at 10 years following vasectomy, indicating that the incidence does not increase or decrease with time. PVPS is thus defined as intermittent or constant unilateral or bilateral testicular pain for greater than 3 months following vasectomy, severe enough to interfere with daily activities and cause the patient to seek medical attention. There are no predictors as to which patients will develop it, there is no clear-cut etiology, and there is no best treatment. The syndrome is not due to infection, so antibiotics are not helpful. Medical treatment options include nonsteroidal anti-inflammatories, scrotal support, nerve blocks, and tricyclic antidepressants. Surgical treatments include conversion to open-ended vasectomy, vasectomy reversal, epididymectomy, orchiectomy (22), and microsurgical neurolysis (24).

Prolonged sexual dysfunction following vasectomy is rare.

Through the years, questions have been raised about an association between vasectomy and a variety of subsequently diagnosed disease states including atherosclerosis, prostate cancer, glomerulonephritis, and primary progressive aphasia. So far, reviews of the initial studies point out methodologic factors, and subsequent studies have not been able to support any association between vasectomy and any disease states (25). In fact, AUA Guideline Statement 3 is a standard: “Clinicians do not need to routinely discuss prostate cancer, coronary heart disease, stroke, hypertension, dementia or testicular cancer in pre-vasectomy counseling of patients because vasectomy is not a risk factor for these conditions.”

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CHAPTER 52 VASOVASOSTOMY AND VASOEPIDIDYMOSTOMY

MATTHEW WOSNITZER AND MARC GOLDSTEIN

VASOVASOSTOMY

Approximately 500,000 vasectomies are performed annually in the United States (1). Up to 6% of men undergoing vasectomy will ultimately request vasectomy reversal for multiple reasons (2). Vasectomy reversal has evolved since its introduction in the early 1900s (3). Modern microsurgical reconstruction has been demonstrated as a safe and efficacious treatment for most cases of vasal or epididymal obstruction using vasovasostomy or vasoepididymostomy, respectively. The majority of patients with obstructive azoospermia postvasectomy maintain normal or near normal exocrine and endocrine function including sperm production in the testis (4). A precise, watertight, mucosa-to-mucosa, tension-free anastomosis of healthy tissue with excellent blood supply is critical to reestablish patency. Microsurgical reconstruction with vasovasostomy was initially described by Sherman Silber (5) and Earl Owen (6) in the 1970s and has been refined over the ensuing decades. Owen (6) reported a patency rate of 98% in his series of 50 patients, and patency rates have more recently approached 99.5% in some series with experienced microsurgeons (7). Cost-benefit analyses have characterized reversal procedures as the most effective and economic management of postvasectomy infertility (8), even in men with previous failed vasectomy reversal (9), demonstrating that microsurgical reconstruction is an important treatment option for appropriately selected patients (10).

Return of adequate numbers of motile sperm with good fertilizing capacity can take 3 to 18 months after a technically successful reversal. This is especially important for men with partners of advanced maternal age. For optimal outcomes, access to a microsurgeon trained in the vasovasostomy and vasoepididymostomy procedures is requisite. With widespread accessibility of in vitro fertilization (IVF) with intracytoplasmic sperm injection (ICSI) using aspirated sperm, the role for complex reconstructive procedures for postvasectomy infertility has been debated. For patients who either prefer to avoid surgical reconstruction or who, for a variety of reasons, may be poor candidates for reconstruction, motile sperm may consistently be retrieved preferably by microsurgical epididymal sperm aspiration (MESA) for IVF with ICSI (11).

Diagnosis

The preoperative workup for men electing vasectomy reversal includes confirmation of previous natural fertility. However, if the patient has no history of prior paternity or if he has obstructive azoospermia without a history of prior vasectomy, further workup is essential. The workup includes full medical and surgical history (see "Prognostic Factors" section) including survey for symptoms of hypogonadism, physical examination, and basic laboratory tests (see "Laboratory Evaluation" section) with semen analysis. The investigation of the male partner should be performed in conjunction with evaluation of the female partner.

Physical Exam

Physical examination provides important information regarding the likelihood for successful vasectomy reversal. This includes inspection for prior surgical scars in the pelvis and inguinal region, evaluation of vasa to rule out absence, and measurement of testicular volume and consistency (small and soft testes are indicative of impaired spermatogenesis). Testicular biopsy may be necessary in some ambiguous cases at the time of proposed reconstruction. Epididymal fullness, irregularity, induration, or ipsilateral hydrocele may predict presence of secondary epididymal obstruction, which necessitates vasoepididymostomy (see "Vasoepididymostomy" section). The vasectomy site should be examined to detect sperm granuloma, vasal gap length, and length of testicular vasal remnant to formulate a surgical plan. Sperm granulomas are detected in 10% to 30% of men undergoing reversal surgery and may serve as a pop-off valve protecting the epididymis from the adverse consequences of increased intratubular pressure (10,12). Presence of a granuloma on the testicular end of the vas is associated with improved intraoperative vasal fluid quality, decreased risk of epididymal obstruction, therefore predicting vasovasostomy instead of vasoepididymostomy on that side, and is a predictor of better microsurgical vasectomy reversal outcomes (12). Increased gap length between the obstructed vasal ends may require inguinal extension of the scrotal incision and additional dissection of the convoluted vas or epididymis to facilitate tension-free anastomosis (see "Vasovasostomy Surgical Technique" section). Testicular vas length is significant because vasectomy performed closer to the testis (in the convoluted vas for example) is characterized by increased intraluminal pressure and greater risk of secondary epididymal obstruction as compared to a vasectomy site further from the testis which theoretically results in decreased intraluminal pressure and therefore a lower risk of secondary epididymal obstruction (13).

Laboratory Evaluation

Semen analysis with examination of centrifuged pellet, to confirm azoospermia on two occasions, is the primary laboratory test obtained prior to vasectomy reversal. Up to 10% of patients will have sperm with tails in the centrifuged pellet at mean 10 years following vasectomy (14), indicating that sperm will be found in the testicular vasal lumen of at least one side which is associated with favorable outcomes. Low semen volume could indicate ejaculatory duct obstruction and should be investigated with transrectal ultrasound. Serum follicle-stimulating hormone (FSH) less than 7.6 IU per L and normal testosterone reflect intact Sertoli and Leydig cell function, respectively. Elevation of FSH suggests poor spermatogenesis in men with small, soft testes, which may require further diagnostic workup and increased requirement for assisted reproductive technologies following vasectomy reversal (15). In men with elevated serum FSH levels or in men without prior fertility, a positive serum antisperm antibody assay confirms active spermatogenesis obviating the need for testicular biopsy before reconstruction (16).

Indications of Surgery

Microsurgical reconstruction is performed for patients desiring additional children and for treatment of postvasectomy pain, iatrogenic (hernia or hydrocele repair, orchiopexy), infectious, or traumatic causes of vasal obstruction. In a series of 472 patients undergoing surgical exploration for obstructive azoospermia, approximately 7% had an iatrogenic injury secondary to inguinal hernia repair (frequently pediatric hernia surgery), renal transplantation, appendectomy, or spermatocelectomy (17). Such patients typically exhibit long vasal defects, impaired blood supply, longer obstructive duration, increased technical complexity of surgery, and poorer outcomes compared to vasectomy reversal patients.

Prognostic Factors

Multiple patient and partner factors affect the outcome of vasectomy reversal and should be assessed during preoperative evaluation. Factors include prior fertility, medical and surgical history subsequent to vasectomy (inguinal hernia repair, previous failed vasectomy reversal, presence of sperm granuloma), obstructive interval, and female partner's age/fertility status. The likelihood of successful pregnancy following vasectomy reversal decreases from 56% in patients whose partners are 20 to 39 years of age to 14% in those whose partners are age 40 years and older (18). Men with the same partners prior to and following vasectomy procedure also have better outcomes, perhaps from proven previous fecundity together and shorter time interval since vasectomy (19). Regarding time interval from initial vasectomy to subsequent vasectomy reversal, patency and pregnancy rates of 91% and 89%, respectively, were identified for obstruction interval of <5 years, whereas patency and pregnancy rates of 89% and 44% for obstruction interval of >15 years were identified (12). The Vasovasostomy Study Group demonstrated similar results with patency and pregnancy rates of 97% and 76%, respectively, for obstruction interval of <3 years, which declined to 71% and 30% for obstruction interval of ≥15 years (20). Determining when vasovasostomy or vasoepididymostomy is performed primarily depends on intraoperative vasal fluid findings.

Alternative Therapy

The alternative to reversal surgery is IVF with ICSI using retrieved sperm. Sperm retrieval is optimally performed by MESA with high yields of good quality sperm and excellent outcomes. Testicular aspiration typically yields motile sperm but far fewer in number and poorer in quality (4,11). Following sperm retrieval, there is no need to synchronize sperm and egg retrieval because outcomes with sperm cryopreservation are equivalent to fresh samples (21–23). Sperm retrieval rates for men with obstructive azoospermia using ICSI are high (96% to 100%) regardless of the etiology for obstruction or the use of testicular versus epididymal sperm (24,25).

Vasovasostomy Surgical Technique

Operating Room Setup

Dual-headed operating microscope with 6× to 32× power magnification is used with foot pedal controls allowing the surgeon to customize zoom and focus the field of view without interrupting surgery (Fig. 52.1). The patient is placed in supine position with all pressure points padded. Following incision and initial dissection, the microscope is used for the entire procedure until closure. Although the operation can be performed in the standing position if preferred, custom-designed microsurgical chairs increase stability of the surgeon's chest and arms (Fig. 52.2). By positioning the surgeon on the patient's right side, the right-handed surgeon is in the optimal location to place the more challenging abdominal end vasal sutures with the forehand.

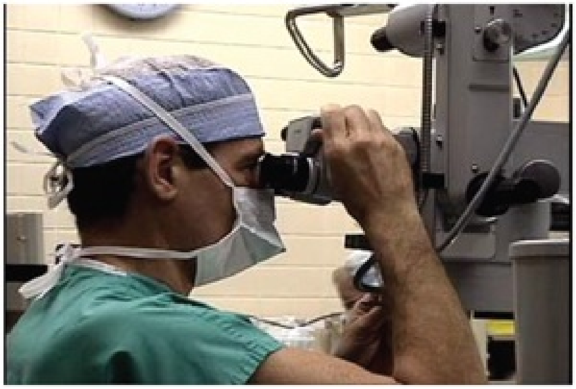

FIGURE 52.1 The operating microscope has two heads for the surgeon and the assistant. Microscope settings are checked before starting the procedure. (All photos courtesy of Marc Goldstein, MD, and Philip S. Li, MD.)

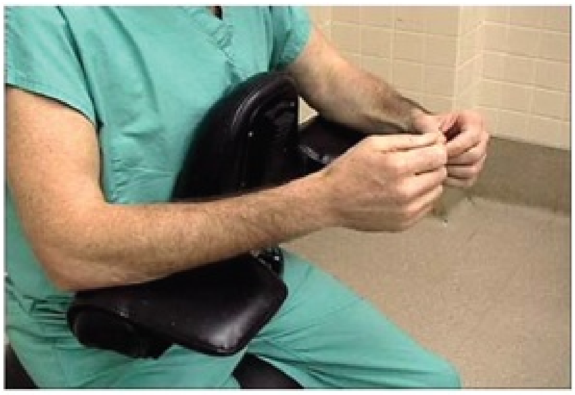

FIGURE 52.2 The specially designed microsurgical chair adjusts for optimal support of the chest and arms.

Anesthesia

Although local or regional anesthesia has been used for uncomplicated vasovasostomy, general anesthesia is preferred. The patient's ability to remain still and the surgeon's experience and comfort level should be considered in selecting the type of anesthesia.

Incision

Following intravenous cefazolin administration and standard surgical preparation of the groin and genitalia in the supine position, the external inguinal ring is marked on both sides (Fig. 52.3). Careful palpation of the vasectomy site assists in determining the required level of the incisions. Following demarcation of the external inguinal ring, high vertical scrotal incisions (at least 1 cm lateral to the base of the penis) provide optimal exposure and cosmetic results. The incision should be adequate to permit delivery of the testis; the tunica vaginalis should be maintained intact for optimal exposure of the vas deferens (Figs. 52.4 to 52.6). The incision may be extended as needed toward the external ring to compensate for high vasectomy site or large vasal gap. If the site of vasal disruption, however, is even higher (such as following inguinal obstruction from herniorrhaphy), an inguinal incision is preferred so that inguinal anastomosis may be completed without tension. Incision through the scar from the previous hernia surgery usually leads directly to the site of obstruction. With this incision, the epididymis may be exposed as needed by delivering the testis through the inguinal incision or via a separate scrotal incision.

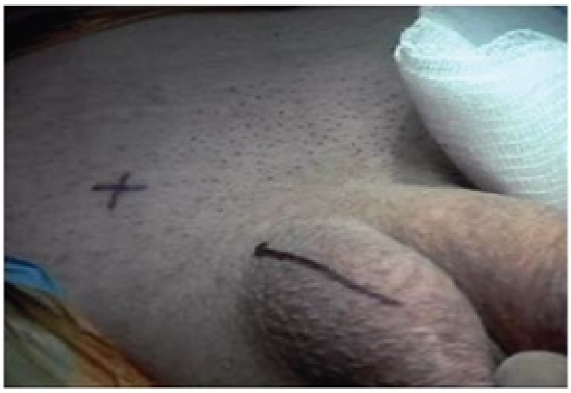

FIGURE 52.3 The right surgical incision is marked over the scrotal skin. The external inguinal ring is marked with an *X*. The incision is at least 1 cm away from the penis.

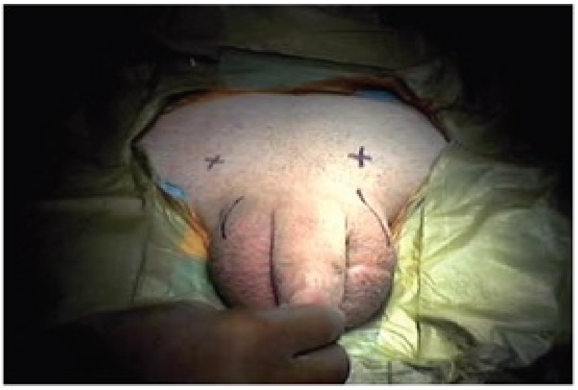

FIGURE 52.4 The skin incision is made with a no. 15 blade.

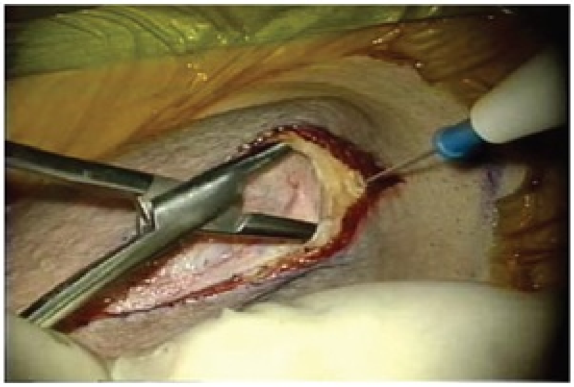

FIGURE 52.5 Electrocautery is used for the underlying dartos layer.

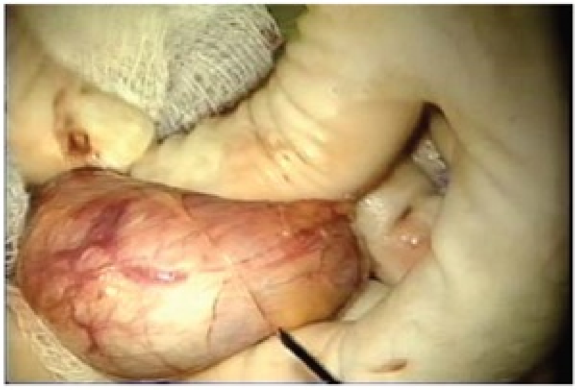

FIGURE 52.6 The testis is delivered into the field, with the tunica vaginalis intact.

Exposure of the Vasa Deferentia

Adequate exposure and meticulous mobilization of the vas deferens is essential for an eventual tension-free anastomosis (Fig. 52.7). To maintain the vasal blood supply, the optimal dissection plane must be established along the vasal sheath; venturing too close to the sheath risks injury to the periadventitial vasal blood supply, whereas too much distance from the sheath may threaten the testicular artery. Injury to the testicular artery may lead to testicular atrophy because the deferential artery likely was disrupted during vasectomy. Mobilization can be performed in part bluntly with a Kittner or gauze-encased fingertip. The operating microscope should be used for this dissection with at least 10× power magnification for sufficient visualization to minimize risk of stripping the vasal vessels. The deferential artery provides the blood supply to the vas deferens (along with the inferior epididymal artery derived from the deferential artery), which originates from the superior or inferior vesicle branches of the internal iliac (hypogastric) artery. Iatrogenic injury to the testicular blood supply (testicular, deferential, and cremasteric arteries) could lead to testicular atrophy.

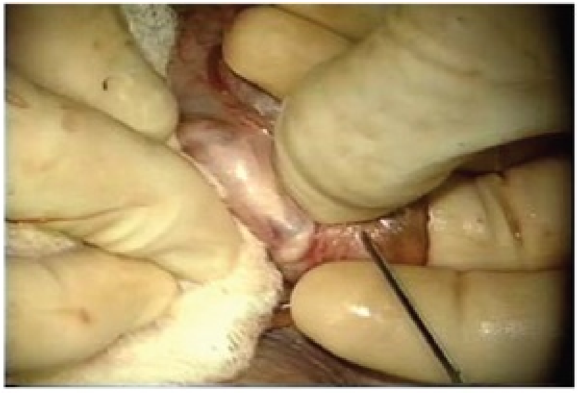

FIGURE 52.7 Blunt dissection with a gauze-covered finger releases the vas deferens from the surrounding tissue.

Following careful blunt dissection of the vas deferens, two Babcock clamps are placed above and below the obstructed segment (Fig. 52.8). With the clamps held with light tension, the proper dissection plane can be entered by transilluminating the sheath with the operating light (Fig. 52.9). Using a curved mosquito clamp, the spaces at two points on either side of the vasectomy site are punctured (Fig. 52.10), and two quarter-inch Penrose drains replace the clamp to serve as handles to manipulate the vas deferens on mild tension while gently separating the vas from surrounding tissue with both blunt and sharp dissection using small fine Metzenbaum scissors (Fig. 52.11).

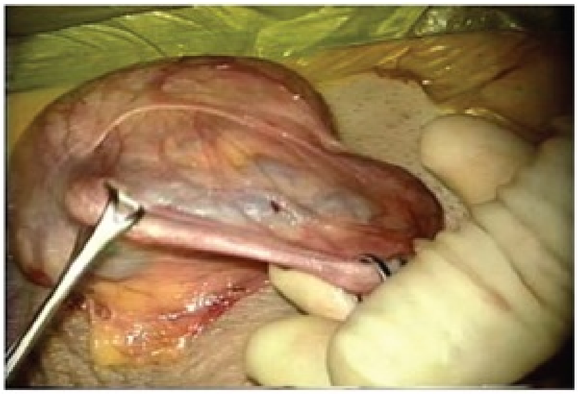

FIGURE 52.8 Two Babcock clamps are placed along the length of the vas deferens.

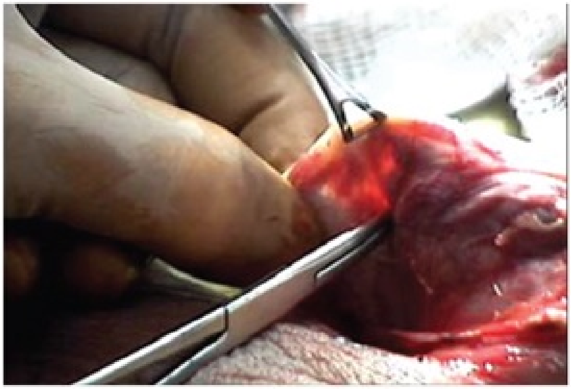

FIGURE 52.9 Transilluminating the tissue surrounding the vas deferens by bringing the operating light low helps to identify the correct dissection plane.

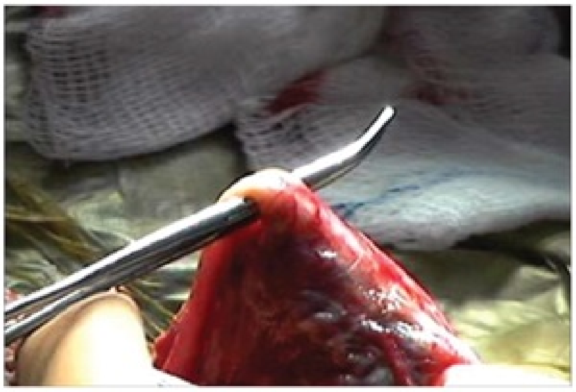

FIGURE 52.10 The plane between the vas deferens and the surrounding tissue is pierced with a Crile clamp.

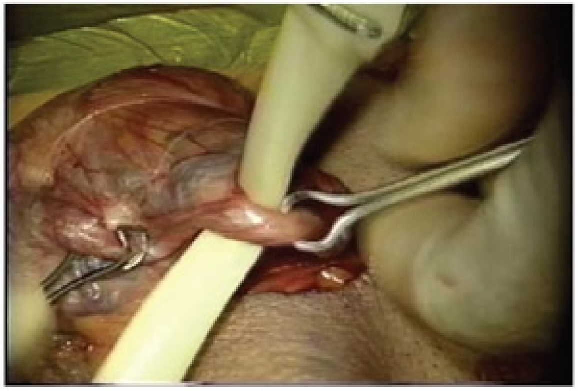

FIGURE 52.11 Quarter-inch Penrose drains are brought through the two openings made by transillumination. Using traction on the Penrose drains, the vas deferens is released using both blunt and sharp dissection.

Multiple techniques can achieve additional length when a long vasal gap would preclude tension-free anastomosis. Blunt dissection using the index finger through the external inguinal ring can free the abdominal vas deferens nearly to the internal inguinal ring level without opening the external oblique aponeurosis. Further, the convoluted vas deferens can be dissected from the epididymal tunica (Figs. 52.12, 52.13, and 52.14A). Up to 6 cm of additional length can be obtained by these techniques. An additional 4 to 6 cm can be released by dissecting the epididymis from the testis, up to two-thirds of the length of the epididymis to the level of the caput epididymis (Fig. 52.14B). During epididymal dissection, the epididymal blood supply (composed of the superior epididymal artery [originating from the testicular artery] and inferior epididymal artery [derived from the deferential artery]) should be recognized and preserved. Additionally, orchidopexy can be performed to reposition the testis higher in the scrotum. Lastly, laparoscopic or robotic mobilization of the intra-abdominal vas may be performed (26,27). The Prentiss maneuver, with placement of the vas medially to the inferior epigastric vessels, may deliver up to 10 cm of vasal length when used in combination with the other methodologies to facilitate subsequent inguinal vasovasostomy.

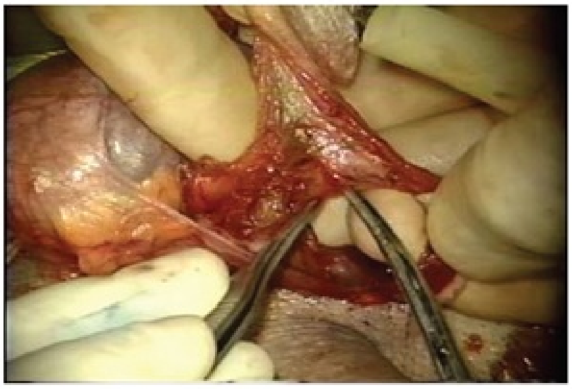

FIGURE 52.12 The vas deferens is freed distally to the level of the convoluted vas.

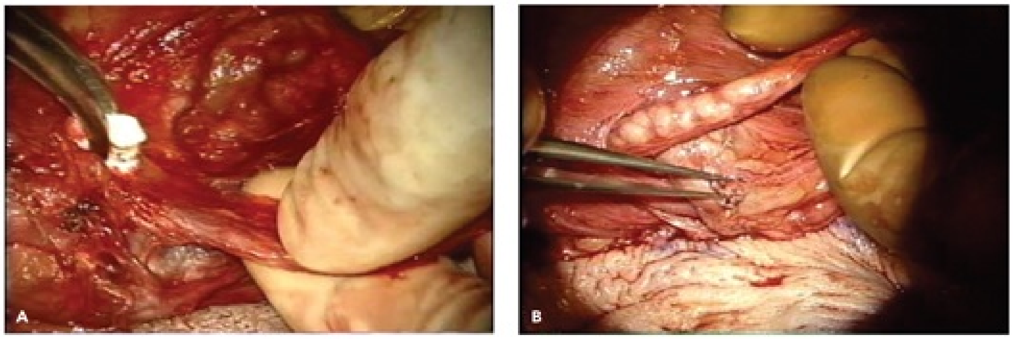

FIGURE 52.13 **A and B:** The convoluted vas deferens is fully exposed.

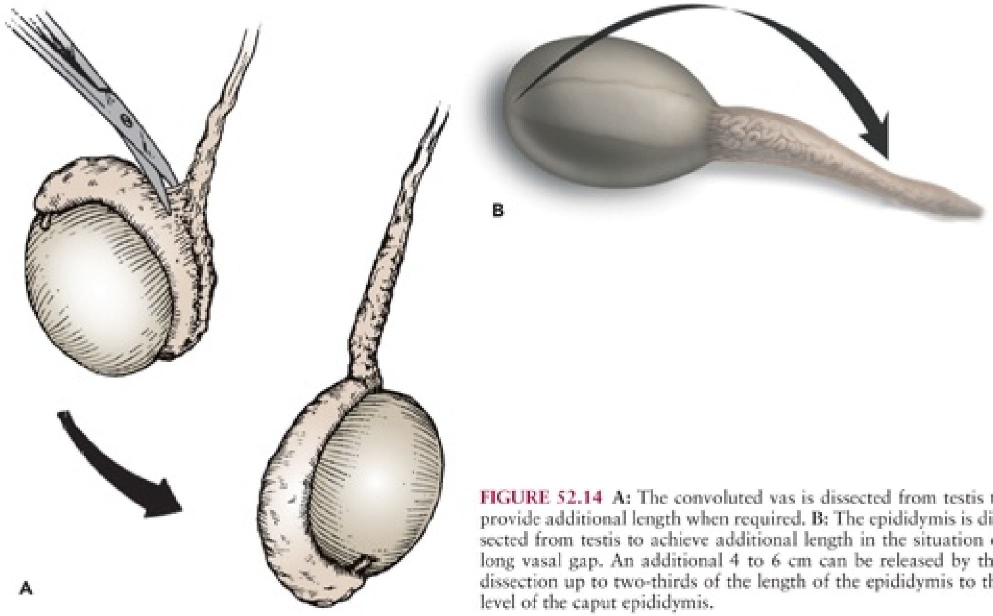

FIGURE 52.14 **A:** The convoluted vas is dissected from testis to provide additional length when required. **B:** The epididymis is dissected from testis to achieve additional length in the situation of long vasal gap. An additional 4 to 6 cm can be released by this dissection up to two-thirds of the length of the epididymis to the level of the caput epididymis.

Preparation of the Vasa Deferentia

The obstructed segment is excised including any associated vasectomy clips or sperm granuloma. Initial excision is performed on the testicular side with an ultrasharp knife and a slotted 2-mm, 2.5-mm, or 3-mm-diameter nerve-holding clamp (Accurate Surgical & Scientific Instruments Corp, Westbury, New York). The slotted nerve-holding clamp permits a perfect 90-degree transection (Figs. 52.14 to 52.16). Under 15× to 25× magnification, three distinct layers are visualized including the mucosa, muscularis, and adventitia. Healthy mucosa should be white and elastic and muscularis should be smooth and supple. Bleeding at each layer represents healthy blood supply. If the blood supply is in question, or if the muscularis is gritty and fibrotic, additional cuts in the same manner should be made until consistently healthy tissue is identified (see Fig. 52.16). The deferential artery and vein are ligated using 6-0 Vicryl. The micro-bipolar coagulation forceps, set at 2.5 to 3.5 watts, controls small bleeders, but caution should be exercised to avoid mucosal thermal injury.

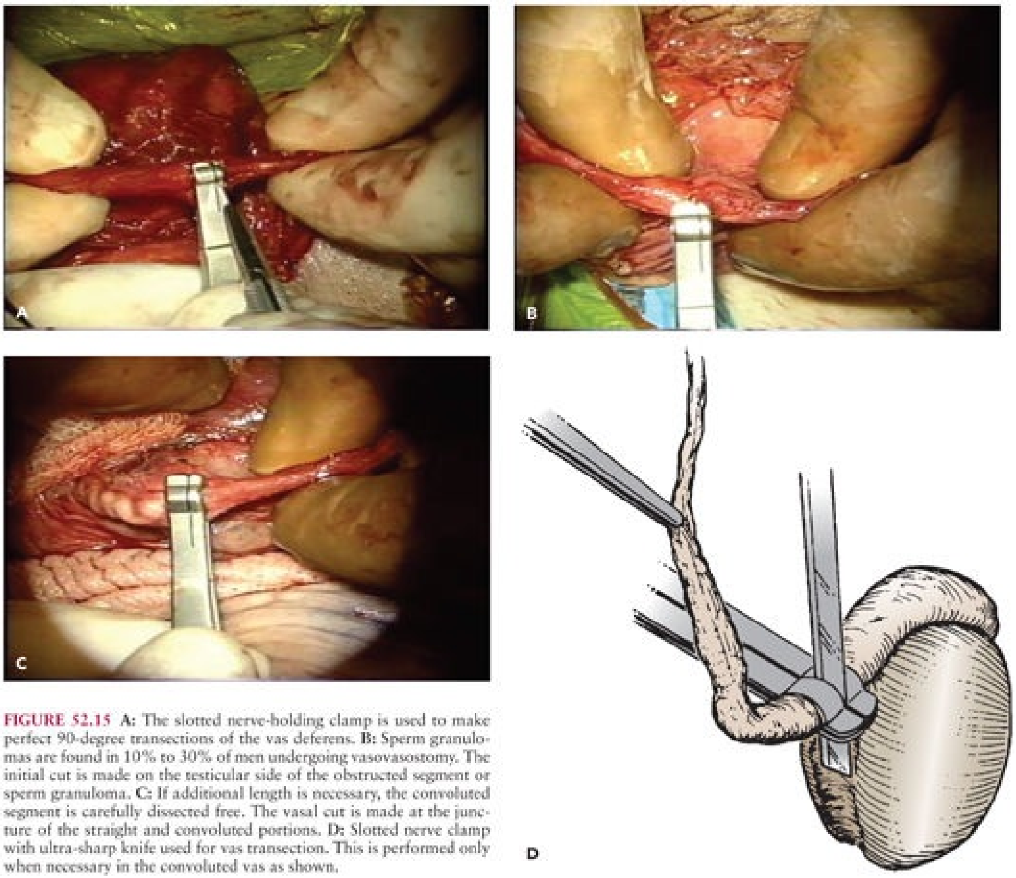

FIGURE 52.15 **A:** The slotted nerve-holding clamp is used to make perfect 90-degree transections of the vas deferens. **B:** Sperm granulomas are found in 10% to 30% of men undergoing vasovasostomy. The initial cut is made on the testicular side of the obstructed segment or sperm granuloma. **C:** If additional length is necessary, the convoluted segment is carefully dissected free. The vasal cut is made at the juncture of the straight and convoluted portions. **D:** Slotted nerve clamp with ultra-sharp knife used for vas transection. This is performed only when necessary in the convoluted vas as shown.

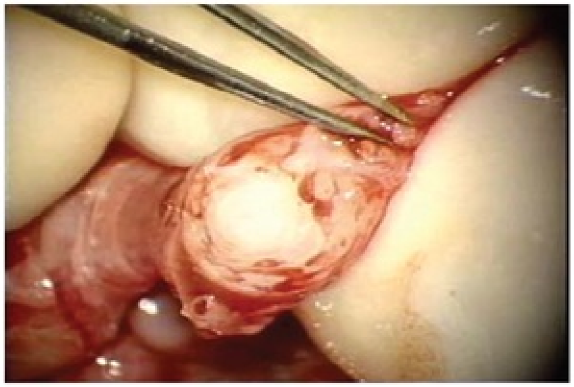

FIGURE 52.16 An unhealthy segment of vas deferens demonstrates white, avascular vasal layers surrounded by fibrotic scar tissue.

Examination of Vasal Fluid

The testicular end of the vas deferens is milked until fluid is expressed and a touch prep is completed using a glass slide (Fig. 52.17). The fluid is mixed with a single drop of lactated Ringer solution and a cover slip is mounted. The slide is immediately examined under 40× power magnification with a separate bench microscope setup in the OR (Fig. 52.18). The Practice Committee of the American Society for Reproductive Medicine (28) (ASRM Guidelines) grades the sperm quality of vasal fluid as follows: grade 1, mainly normal motile sperm; grade 2, mainly normal nonmotile sperm; grade 3, mainly sperm heads; grade 4, only sperm heads; and grade 5, no sperm. Vasovasostomy is the ideal approach for grades 1 through 4. If no sperm are identified in the vasal fluid (grade 5), the gross appearance of the vasal fluid is used to select between vasovasostomy and vasoepididymostomy (Table 52.1). Copious, crystal clear waterlike fluid squirting from the testicular end of the vas even when no sperm are found in this fluid initially is usually associated with return of sperm to the ejaculate after vasovasostomy. In fact, resampling of the fluid again just prior to tying the last mucosal suture often reveals rare long-tailed, even motile, sperm. Thick, white, water-insoluble toothpaste-like material indicates epididymal obstruction necessitating vasoepididymostomy (Fig.

52.19). Although a standard algorithm has not been established, vasovasostomy is completed when complete sperm or copious sperm heads, especially with occasional short tails, are identified in the vasal fluid or when fluid is copious and watery. Vasoepididymostomy should be elected if the vasal sperm is absent after barbitage or if the fluid is thick, white, and creamy and devoid of sperm or sperm parts. If no fluid can be expressed for evaluation, the testicular end of the vas deferens is barbitaged with 0.1 mL of saline using a 24-gauge angiocatheter sheath, and the expressed fluid is examined (Fig. 52.20). With large sperm granulomas, the testicular end of the vas is minimally dilated with very little or no luminal fluid; barbitage with milking often expresses a small amount of fluid containing long-tailed, even motile, sperm.

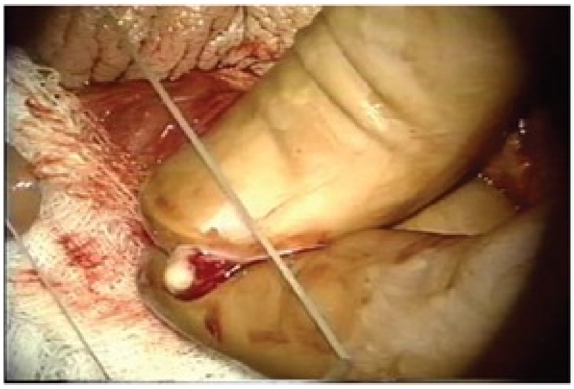

FIGURE 52.17 A touch prep of the vasal fluid is made by blotting the freshly cut testicular portion of the vas deferens onto a glass slide.

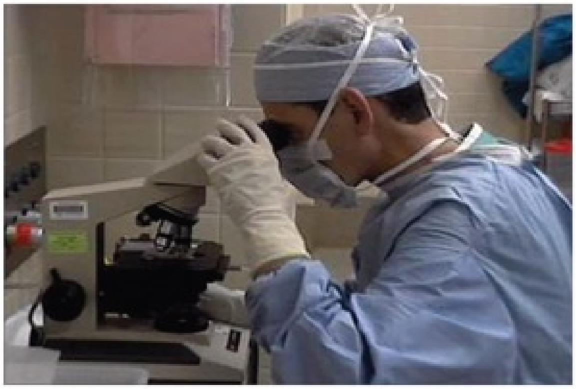

FIGURE 52.18 A separate microscope setup should be used to examine the vasal fluid under 40× magnification.

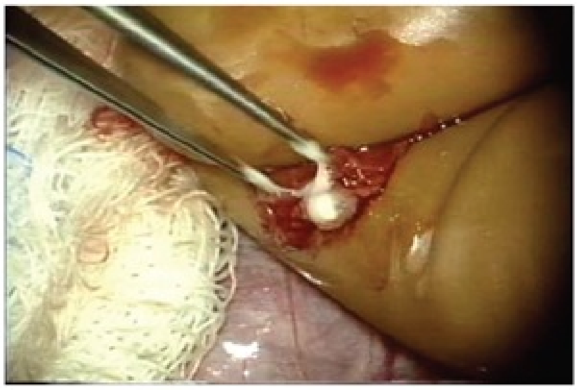

FIGURE 52.19 A thick, greasy, "toothpaste" consistency indicates a poor prognosis for sperm in the vasal fluid.

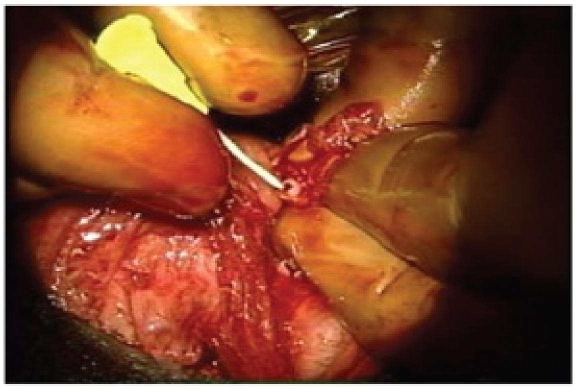

FIGURE 52.20 If the vas deferens is "dry," a 24-gauge angiocatheter sheath is used to barbitage the lumen with saline.

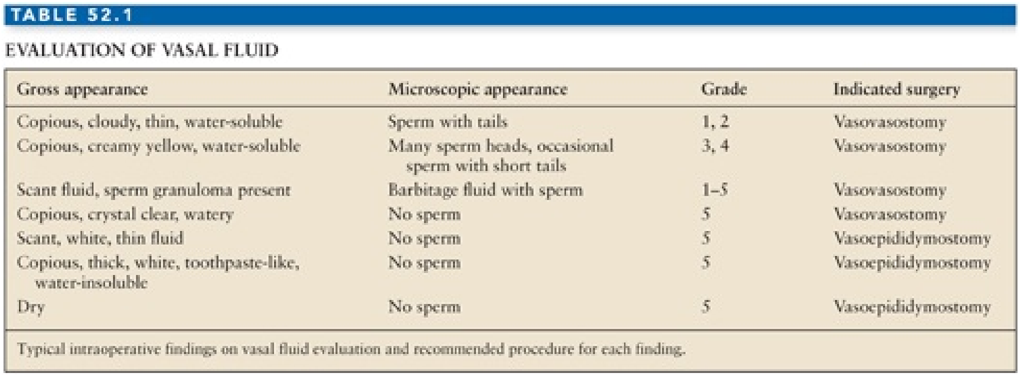

TABLE 52.1

EVALUATION OF VASAL FLUID

Gross appearance	Microscopic appearance	Grade	Indicated surgery
Copious, cloudy, thin, water-soluble	Sperm with tails	1, 2	Vasovasostomy
Copious, creamy yellow, water-soluble	Many sperm heads, occasional sperm with short tails	3, 4	Vasovasostomy
Scant fluid, sperm granuloma present	Barbitage fluid with sperm	1–5	Vasovasostomy
Copious, crystal clear, watery	No sperm	5	Vasovasostomy
Scant, white, thin fluid	No sperm	5	Vasoepididymostomy
Copious, thick, white, toothpaste-like, water-insoluble	No sperm	5	Vasoepididymostomy
Dry	No sperm	5	Vasoepididymostomy

Typical intraoperative findings on vasal fluid evaluation and recommended procedure for each finding.

The abdominal end of the vas deferens is similarly transected and inspected. The lumen is gently dilated with a microvessel dilator and approximately 1 mL of saline is gently injected with a tuberculin (TB) syringe attached to a 24-gauge angiocatheter sheath to confirm patency without resistance. If there is any question, a Foley catheter with 5-mL balloon (inflated with air) is placed gently against the bladder neck. One milliliter of indigo carmine (1:1 ratio with lactated Ringer) is injected into the abdominal vas, with blue urine confirming patency. Additional tests to identify obstruction location include passage of a 2-0 prolene suture (non-needle end) into the lumen of the abdominal vas (with a clamp placed on the suture when it meets obstruction) to calculate distance to the location of an inguinal obstruction. Finally, formal vasogram may be completed with 0.5 mL of injected water-soluble radiographic contrast injected using a no. 3 whistle-tip ureteral catheter to identify obstruction while a Foley catheter with 5 mL balloon is placed gently against the bladder neck. Vasography must be performed with microsurgical technique because poor vasotomy closure can result in stricture formation, sperm granuloma, or obstruction at the vasography site. In assessing patency of the testicular and abdominal ends of the vasa deferentia, the surgeon must assess both the left and right sides before proceeding with reconstruction. Often, a crossed vasovasostomy or vasoepididymostomy is the best solution for complex problems such as a patent abdominal vas on one side where there is also epididymal obstruction, or a nonfunctioning testis and an obstructed inguinal vas or ejaculatory duct on the contralateral side where sperm are found in the testicular vas.

Vasovasostomy: Anastomosis of the Vasa Deferentia

In preparation for the anastomosis, the two ends of the vas deferens are stabilized without tension with a microspike approximating clamp (Fig. 52.21) (29). A tongue blade encased in a 1-inch Penrose drain provides a suturing platform (Fig. 52.22). The entire setup is brought up through a slit in a rubber dam (Fig. 52.23). The rubber dam provides a contrasting field for the black suture visualization and prevents sutures from adhering to surrounding tissue.

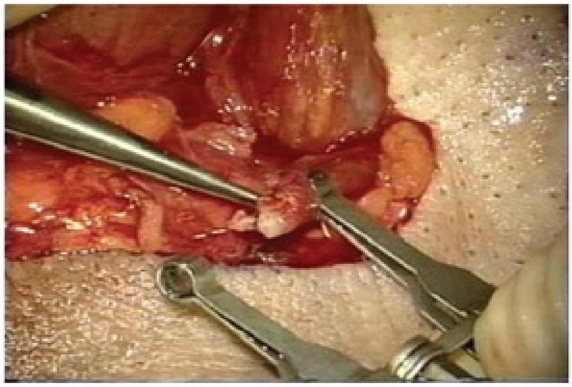

FIGURE 52.21 The microspike approximating clamp stabilizes the two ends of the vas deferens for suturing.

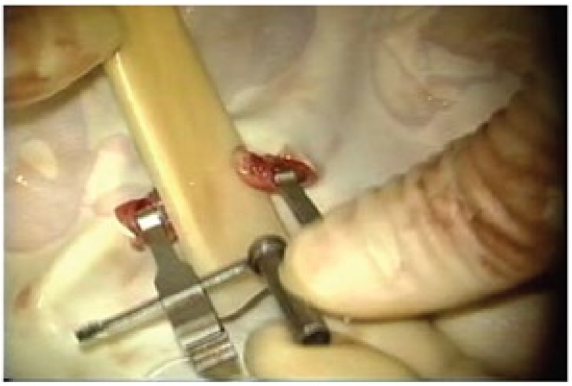

FIGURE 52.22 A tongue blade wrapped with 1-inch Penrose drain provides a platform for suture placement.

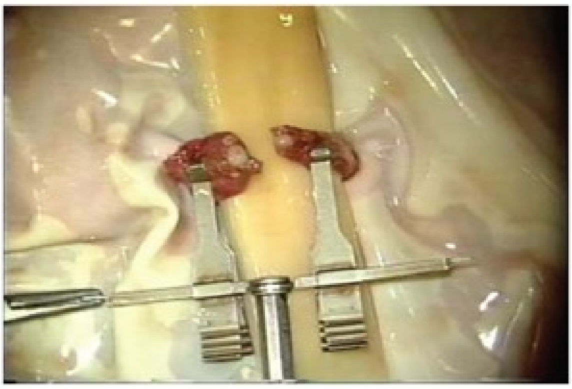

FIGURE 52.23 A rubber dam prevents sutures from sticking and getting lost in the surrounding tissue.

Microdot Technique for Multilayer Microsurgical Vasovasostomy

A microtip marking pen (Devon Skinmarker Extra Fine no. 151, Devon Industries, Buffalo, New York) is used to apply six equidistant dots on the face of each transected vas deferens; the dots of one vasal end should mirror those of the other end to obviate twisting or distortion of the anastomosis (Fig. 52.24A1, 52.24B, and 52.24C). The dots are made at 1, 3, 5, 7, 9, and 11 o'clock positions on the muscularis, approximately halfway between the adventitia and the mucosa. Unlike a single-layer anastomosis, this blueprint ensures precise suture placement and an ultimately watertight multilayer closure even with markedly discrepant luminal diameters (7,20).

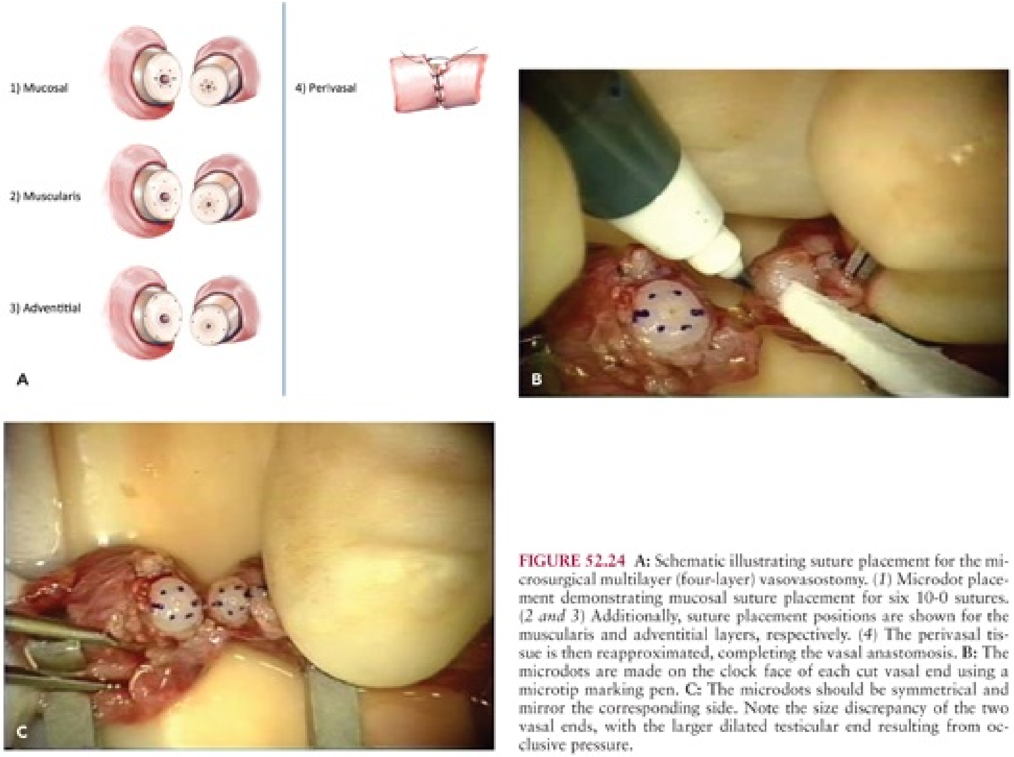

FIGURE 52.24 **A:** Schematic illustrating suture placement for the microsurgical multilayer (four-layer) vasovasostomy. (*1*) Microdot placement demonstrating mucosal suture placement for six 10-0 sutures. (*2 and 3*) Additionally, suture placement positions are shown for the muscularis and adventitial layers, respectively. (*4*) The perivasal tissue is then reapproximated, completing the vasal anastomosis. **B:** The microdots are made on the clock face of each cut vasal end using a microtip marking pen. **C:** The microdots should be symmetrical and mirror the corresponding side. Note the size discrepancy of the two vasal ends, with the larger dilated testicular end resulting from occlusive pressure.

Six monofilament 10-0 nylon double-armed sutures with 70-micron-diameter taper-point needles (Sharpoint, Surgical Specialties Corp, Reading, Pennsylvania, or Ethicon, Inc, Somerville, New Jersey) are placed initially at the three anterior positions in the mucosal layer (Figs. 52.25 and 52.26). Each suture begins within the lumen and exits at the dot. Such inside-out placement of the sutures minimizes mucosal manipulation and reduces risk of back-walling of the vas lumen. The mucosal lumen can be stained with indigo carmine and the tiny abdominal-side lumen gently dilated with the microvessel dilator just prior to suture placement (Fig. 52.27). Although methylene blue causes an immediate reduction in sperm motility and should be avoided in reversal surgery, indigo carmine may be safely used (30). Each suture should include a small amount of mucosa and one-third to one-half of the muscularis, with equal amounts of tissue included on each side. After the three anterior mucosal sutures are tied (Fig. 52.28A), the second layer of two monofilament 9-0 nylon deep muscularis sutures are placed in between these three, without including the mucosa, and tied (Figs. 52.24A2, 52.28B, and 52.28C).

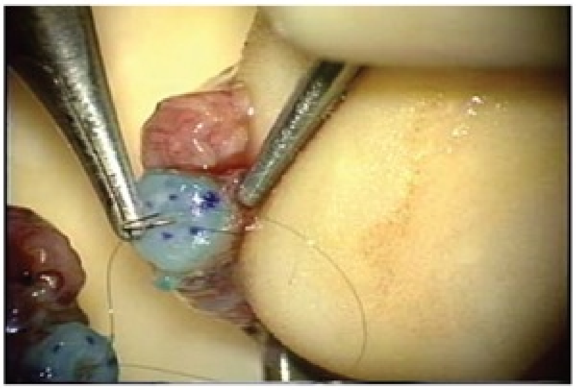

FIGURE 52.25 The placement of the 10-0 nylon mucosal sutures is guided by the microdots. Additional fine-tuning of the suture placements can be made at the surgeon's discretion.

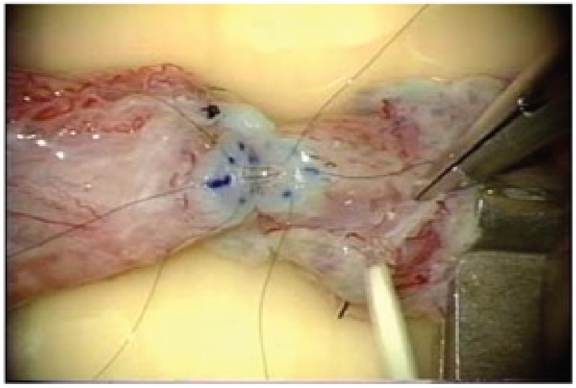

FIGURE 52.26 Three anterior mucosal sutures are placed and tied.

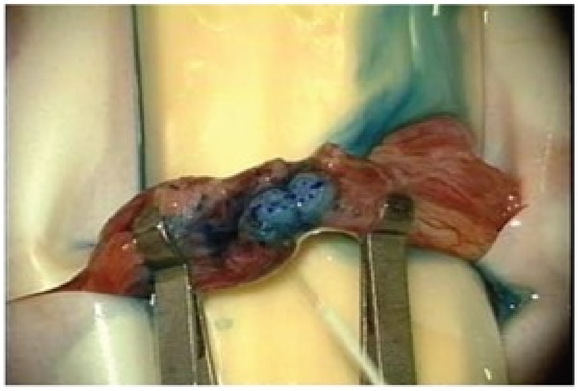

FIGURE 52.27 Visualization of the mucosal edge is improved with the application of indigo carmine.

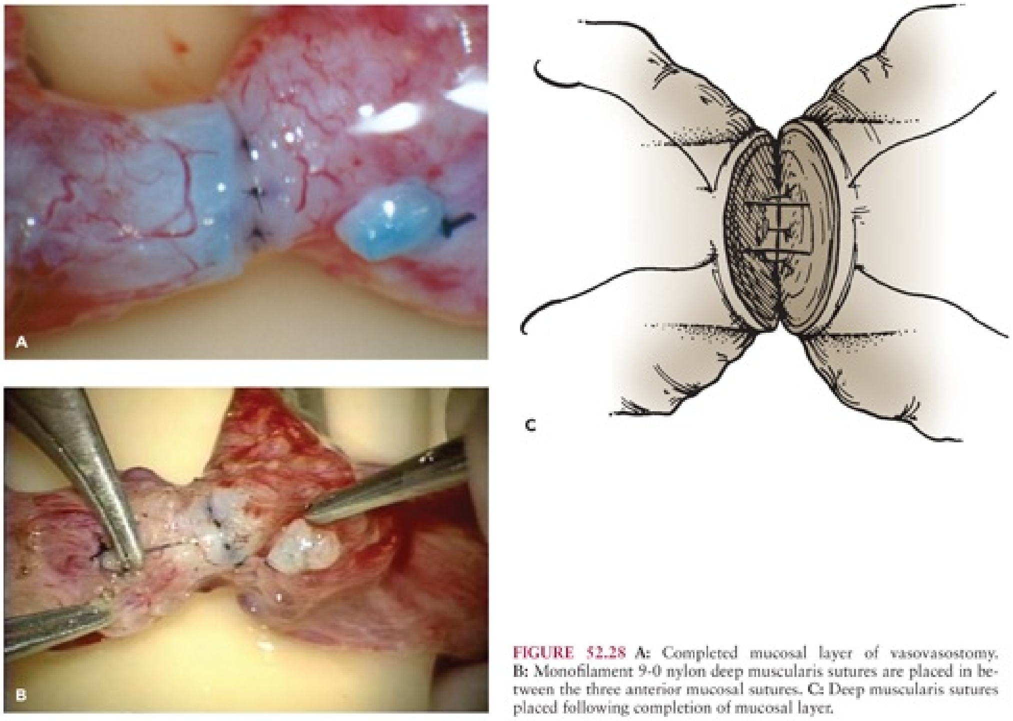

FIGURE 52.28 A: Completed mucosal layer of vasovasostomy. B: Monofilament 9-0 nylon deep muscularis sutures are placed in between the three anterior mucosal sutures. C: Deep muscularis sutures placed following completion of mucosal layer.

The vas deferens is then rotated 180 degrees and the remaining three mucosal sutures are placed in a similar fashion (Fig. 52.29A–C). Prior to tying of the final mucosal suture, the vasal lumen is irrigated with heparinized lactated Ringer solution to inhibit clot formation. Four deep muscularis 9-0 monofilament sutures are placed between the recently placed mucosal sutures for a circumferential two-layer closure (see Fig. 52.24A2). Four to six monofilament 9-0 nylon sutures placed between the deep muscularis sutures within the adventitia constitute the third layer of closure (Figs. 52.24A3, 52.30A, and 52.30B). Finally, the vasal sheath is reapproximated using six interrupted 8-0 nylon sutures which protect the anastomosis from tension and enhance vascularization across the anastomosis (Figs. 52.24A4, 52.30C, and 52.31).

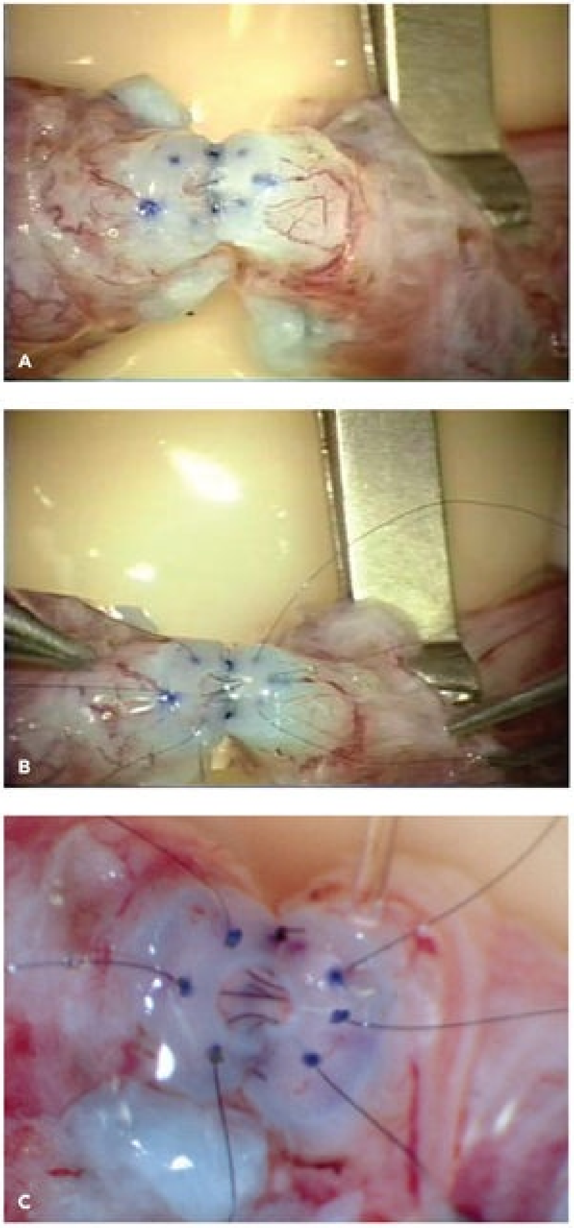

FIGURE 52.29 **A:** The vas deferens is rotated 180 degrees for placement of the remaining sutures. **B:** The sutures are placed in the same sequence as on the other side. **C:** Magnified view of placed mucosal sutures prior to tying. Mucosal sutures placed on second side prior to tying.

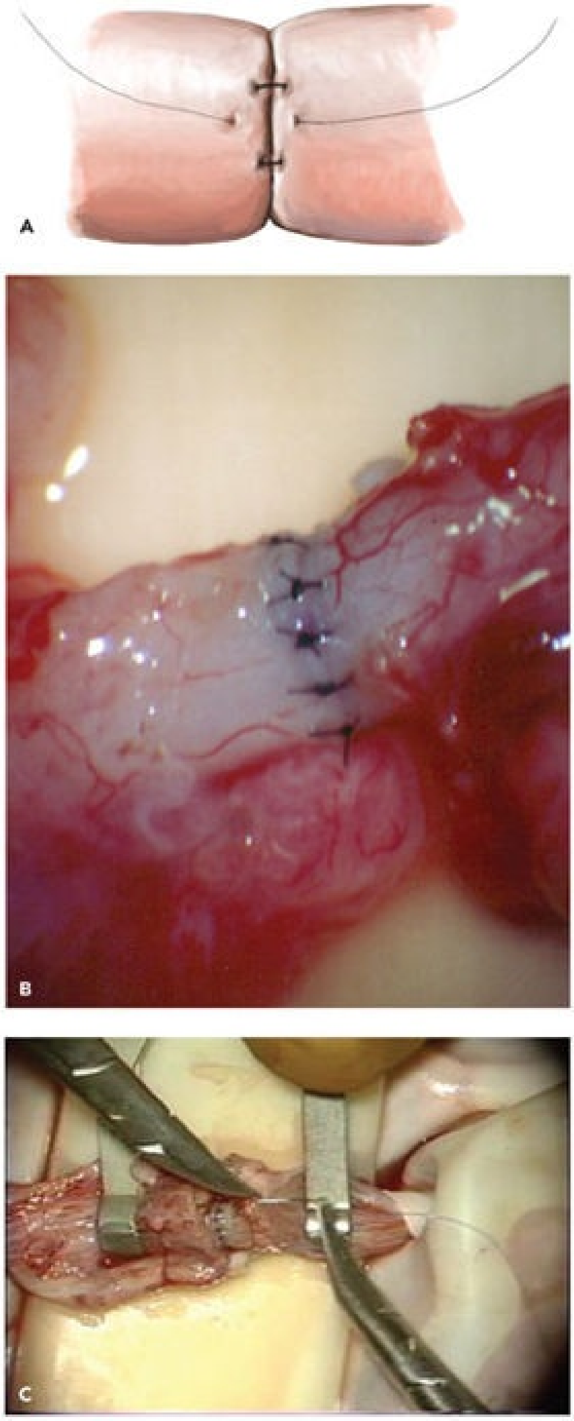

FIGURE 52.30 **A:** Following completion of muscularis layer, adventitial layer is completed (see also Fig. 52.24A3). **B:** Completed mucosal, muscularis, and adventitial sutures of anastomosis. **C:** The vasal sheath is then reapproximated with 8-0 nylon sutures, covering and protecting the anastomotic sutures.

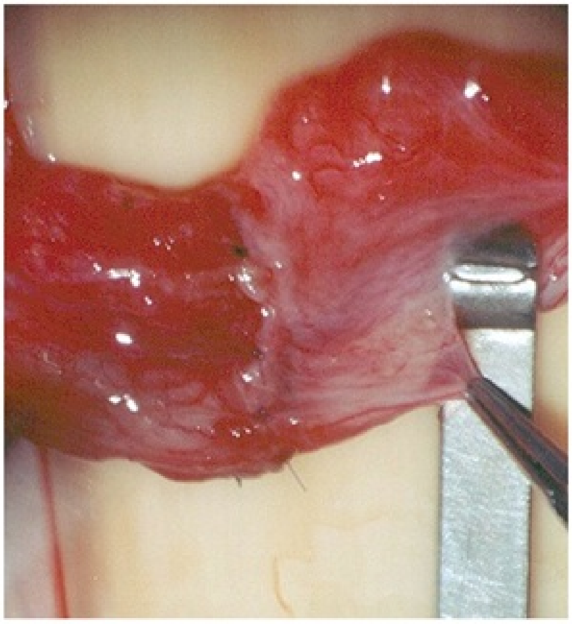

FIGURE 52.31 Completed vasovasostomy multilayer anastomosis with precise apposition of vasal ends in watertight fashion.

Vasovasostomy outcomes are optimized by mucosa-to-mucosa approximation of healthy well-vascularized tissue with minimal handling using atraumatic technique. The anastomosis should be leak-proof and tension-free. Because sperm are highly antigenic, precise anastomosis is required because sperm leakage can develop into a sperm granuloma and provoke an inflammatory reaction, potentially leading to failure of vasovasostomy (7,31). Tension on the anastomosis may result in delayed stricture and failure after an initial period of sperm in the ejaculate.

Closure

Following completion of the four-layer anastomosis, the dartos layer is reapproximated with interrupted 4-0 Monocryl followed by subcuticular skin closure with 5-0 Monocryl (Fig. 52.32). Penrose drains may be required with extensive dissection (Fig. 52.33). If drains are used, explicit instructions are provided for the patient to remove them at home the following day.

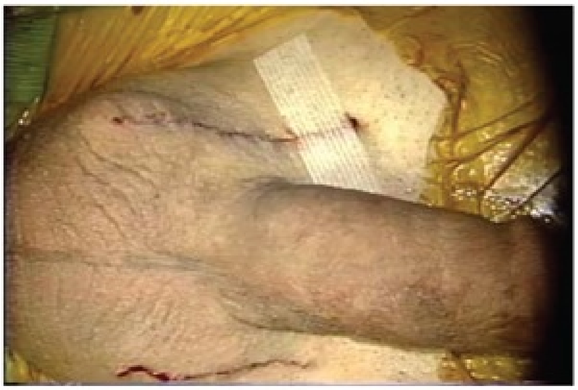

FIGURE 52.32 After closure, the nonscrotal portion of the incision is reinforced with adhesive skin-closure strips.

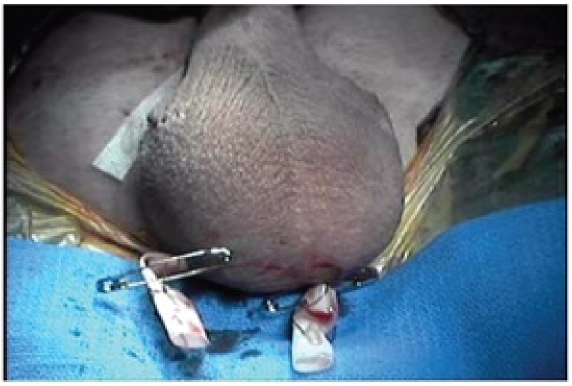

FIGURE 52.33 Penrose drains exiting the dependent portion of the scrotum provide wound drainage for cases involving extensive dissection.

Special Circumstances

If unhealthy tissue or blood supply results in cutback of the testicular portion of the vas deferens to the convoluted segment (Figs. 52.13A, 52.13B, and 52.14), anastomosis to the convoluted portion of the vas deferens uses the same principles as the standard anastomosis, with several additional considerations. A perfect 90-degree transection must be achieved; the convoluted segment is even more vulnerable to an oblique cut, resulting in insufficient mucosa and muscularis on one side. During dissection, care should be taken to preserve the blood supply without unraveling the convoluted vas. During suturing, taking too large bites of the convoluted segment increases the risk for perforation or obstruction of adjacent convolutions. Among patients undergoing vasectomy reversal involving the convoluted vas deferens, the patency and natural pregnancy rates range from 88% to 98% and 48%, respectively, comparable to outcomes with standard techniques (32,33).

The fundamental guiding principle is that one good anastomosis is superior to two tenuous connections. For example, if right epididymal obstruction and a left abdominal vas blockage are encountered, a single transeptal crossed vasovasostomy should be performed. Specifically, crossed vasovasostomy should be considered in the following circumstances: (a) unilateral inguinal obstruction of the vas deferens with an atrophic contralateral testis or (b) obstruction or aplasia of the inguinal vas or ejaculatory duct with a contralateral epididymal obstruction. Although this technique requires making a copious opening of the scrotal septum, it is greatly preferably to inguinal vasovasostomy.

In a less frequently encountered scenario, significant shortage of vasal length during a crossed vasovasostomy may warrant a testicular transposition (34). This maneuver takes advantage of the superior length of the spermatic cord to the vas deferens. Tension on the vas deferens is relieved by transferring the testes to the contralateral hemiscrotum via an opening in the septum. If multiple vasal obstructions are identified, such as concomitant ipsilateral vasectomy and inguinal hernia repair, two simultaneous vasovasostomies cannot be performed because blood supply to the intervening segment would be compromised. These situations are often solved with crossed vasovasostomy, vasoepididymostomy, and, if reconstructible bilaterally, epididymal aspiration with cryopreservation for future IVF/ICSI.

Postoperative Care and Follow-up

Vasectomy reversal is performed on an ambulatory basis. Prior to discharge, bacitracin ointment and sterile gauze dressing are applied to the closure site, followed with fluff-type gauze and snug-fitting athletic supporter. The supporter should be worn at all times, even at night, for 6 weeks. Thereafter, the supporter is worn during athletic activity until pregnancy is achieved. Light activity may be resumed in 3 days and heavy activity in 3 weeks. The patient is advised to avoid sexual activity and ejaculation for 4 weeks. Postoperative pain control includes hydrocodone with acetaminophen and a nonsteroidal anti-inflammatory drug. Semen analyses are obtained at 1, 3, and 6 months after surgery and every 6 months thereafter.

Complications

Vasovasostomy is a safe procedure with low risk for significant complications. Hematoma formation is the most common acute complication of vasectomy reversal surgery, occurring in 0.3% of patients in our series of 2,100 cases (M. Goldstein, unpublished data). All resolved in 6 to 12 weeks with conservative management. No wound infections occurred. Sperm granulomas, which often precede eventual obstruction, formed in about 5% of our patients (M. Goldstein, unpublished data). Obstruction and recurrent stricture with secondary azoospermia are other possible complications (35).

VASOEPIDIDYMOSTOMY

Vasal obstruction from prior vasectomy may promote increased intraluminal pressure, microrupture, and obstruction of delicate epididymal tubules leading to secondary epididymal obstruction in up to 60% of men 15 years postvasectomy (36). If iatrogenic postvasectomy vasal obstruction is excluded, primary obstructive azoospermia occurs most commonly due to bilateral obstruction of the epididymides. Optimal management of obstructive azoospermia resulting from epididymal obstruction includes microsurgical reconstruction with vasoepididymostomy.

Vasoepididymostomy (VE) is a safe, efficacious procedure but is considered to be the most technically challenging surgery among male reproductive microsurgical procedures. Following early reports of VE with low success rates, the application of the operating microscope in the late 1970s for microsurgical end-to-end single-tubule anastomosis (introduced by Silber) (37) and end-to-side anastomosis (described by Wagenknecht et al.) (38) initiated the modern era of VE with patency rates of up to 50% and 70%, respectively. Berger (39) popularized a triangulation technique using tubular intussusception with three double-armed microsutures placed to an epididymal tubule in a triangular manner. Marmar (40) subsequently altered this technique to include only two microsutures placed perpendicularly to the epididymal tubule for the anastomosis. Chan et al. (41) pioneered the placement of these two microsutures longitudinally in relation to the epididymal tubules, facilitating longitudinal incision of the tubules (longitudinal intussusception vasoepididymostomy [LIVE]) with increased lumen diameter for epididymal inflow at the anastomosis (42). The LIVE technique, our technique of choice, establishes precise apposition of the vasal lumen (300 to 400 μm) to the epididymal tubule lumen (150 to 250 μm) and has resulted in improved vasoepididymostomy outcomes (see “Outcomes” section). The advantages of the LIVE technique include providing 4-point fixation at the mucosal anastomosis using two double-armed microsutures. The LIVE technique’s watertight outer-layer anastomosis between the vasal sheath and epididymal tunic is crucial to avoid leakage of fluid, which can lead to formation of sperm granuloma (43).

Diagnosis

A comprehensive history and physical examination provides essential information that may confirm the diagnosis of epididymal obstruction. The most frequent cause of epididymal obstruction in the United States is prolonged vasal obstruction following vasectomy. Additional history suggesting alternate causes of obstruction includes prior epididymitis or orchitis, surgery, instrumentation, or trauma to pelvis, scrotum, prostate, or urethra. Family history of cystic fibrosis indicates that the patient could be a carrier of mutations in the cystic fibrosis transmembrane conductance regulator (CFTR) gene which is associated with congenital unilateral absence of vas deferens (CUAVD) or bilateral absence of vas deferens (CBAVD) with concomitant epididymal obstruction.

Physical examination should include comprehensive assessment of the scrotum, vas deferens, testes, and epididymides. Findings indicative of epididymal obstruction include vasectomy (performed in the proximal convoluted vas), abnormal epididymis (full, indurated, or irregular), epididymal cysts with normal testicular volume and texture, and extended duration since vasectomy (12,20,44,45). The presence of vasal sperm granuloma reduces the risk of epididymal obstruction (12). CBAVD on scrotal examination represents another finding consistent with obstruction of the excurrent ductal system. Semen analyses demonstrating azoospermia with normal ejaculation volume, pH, and fructose level are consistent with isolated bilateral epididymal obstruction which should especially be investigated with extended CFTR genetic testing panels and female partner testing for men who demonstrate abnormalities (46–48).

The diagnoses of unilateral obstruction and partial epididymal obstruction are challenging to confirm, as these patients generally do not present with azoospermia, but rather with infertility with any combination of oligospermia, asthenospermia, and teratospermia. If unilateral or partial epididymal obstruction is suspected clinically, and vasoepididymostomy or other surgical reconstruction of the excurrent ductal system is considered, cryopreservation of sperm preoperatively should be considered as the semen profile may potentially decline significantly postoperatively if the reconstructive surgery is unsuccessful.

Epididymal obstruction is confirmed intraoperatively, with the presence of active spermatogenesis within the testis and the absence of sperm in a patent vas deferens. Although additional testing including cystoscopy, scrotal and transrectal ultrasound, computerized tomography, and magnetic resonance imaging may contribute information that is consistent with epididymal obstruction, these studies are not sufficiently sensitive or specific to diagnose epididymal obstruction and are generally not required before vasoepididymostomy.

A positive serum antisperm antibody assay confirms active spermatogenesis and obviates the need for a testis biopsy (16). Active spermatogenesis must be confirmed prior to reconstruction of the excurrent ductal system. If the antisperm antibody assay is negative, which is the case in 30% of men who are obstructed, confirmation of active spermatogenesis may be completed by bilateral testicular biopsy performed either as an isolated preliminary procedure or at the time of planned reconstruction in the event that the epididymal tubules are dilated. The presence of many sperm on a touch or squash prep confirms active spermatogenesis (4). Alternatively, cytologic examination of a percutaneous testicular aspiration for spermatozoa may confirm the presence of active spermatogenesis.

Indications

Vasoepididymostomy is the indicated management for obstructive azoospermia due to epididymal obstruction. Vasoepididymostomy should be performed using an epididymal tubule containing abundant sperm (motile or immotile) or sperm parts (heads and tails). Absence of abundant sperm or sperm parts indicates that the level of epididymal obstruction is located more proximally (toward the testicle), where the anastomosis should be performed. Vasoepididymostomy should not be attempted in the absence of vasa, when the vasal gap is too large to facilitate a tension-free anastomosis regardless of appropriate surgical maneuvers for tissue mobilization, or in the case of azoospermia due to nonobstructive azoospermia (primary testicular failure).

Alternative Therapy

In addition to microsurgical vasoepididymostomy, men with azoospermia resulting from epididymal obstruction (similar to those with vasal obstruction) may have surgical sperm retrieval from the epididymides (microscopic [MESA] or percutaneous [PESA] epididymal sperm aspiration) or from the testes (testicular sperm aspiration [TESA] or testicular sperm extraction [TESE]) for IVF/ICSI to achieve pregnancy with their partners (22). With the increasing availability and use of assisted reproductive technologies, the safety and efficacy of these technologies have improved significantly, although there is a small increase in birth defects and other abnormalities in offspring of babies conceived with IVF/ICSI (49). For couples with female partners of advanced reproductive age or with significant female-factor infertility, sperm retrieval in combination with ICSI can facilitate early conception (50).

Vasoepididymostomy Surgical Technique

For vasoepididymostomy, general anesthesia is preferred because even small movements are magnified by the operating microscope and may affect the anastomosis. In the absence of any clinical evidence of complicated obstruction, regional anesthesia with sedation can be employed in cooperative and motivated patients. Intraoperative intravenous antibiotics are used.

Preparation of the Vas

A high scrotal incision (see Fig. 52.3) facilitates adequate mobilization of the inguinal portion of the vas for tension-free anastomosis with the epididymis. When isolating the vas, its periadventitial sheath should not be stripped off because this would sacrifice its blood supply (see “Vasovasostomy,” “Exposure of the Vasa Deferentia” section). Because the epididymis naturally lies laterally in the posterior aspect of the testis, the vas should be mobilized and isolated lateral to the spermatic cord to permit direct contact with the epididymis for the anastomosis. For patients with previous vasectomy, the vas should be transected at the vasectomy site to determine whether the testicular vas contains sperm and whether a vasoepididymostomy is indicated. The cut surface of the testicular end of the vas deferens is inspected with the operating microscope under 15× to 25× magnification. A healthy, white, smooth, soft mucosal ring should be observed that springs back immediately following gentle dilation with a 2- to 3-mm microvessel dilator. If the blood supply is poor, the vas should be recut until healthy tissue is found.

In patients with primary epididymal obstruction without previous vasectomy, the vas is isolated at the junction of the straight and convoluted vas, where it is hemitransected with a 15-degree ophthalmic knife (see Fig. 52.13B). Vas transection at this site allows maximal length of straight vas to be preserved for a tension-free vasoepididymostomy. Vasal fluid is sampled and then evaluated under light microscopy. Absence of sperm and sperm parts in the vasal fluid indicates epididymal obstruction. By contrast, the presence of abundant motile sperm indicates the absence of epididymal obstruction, and evaluation of vasal patency distally (abdominal end) is essential to identify the location of the obstruction (see Fig. 52.20). Patency of the abdominal end of the vas should be confirmed by saline vasogram as described (in “Vasovasostomy” section). If patency is not certain, a dye vasogram with diluted indigo carmine should be performed as described. If patency is not confirmed, formal vasography can be used to locate the obstruction. Proper technique must be followed with gentle instillation of fluid because improper technique can result in stricture, granuloma formation, or obstruction. If obstruction toward the seminal vesicle end of the vas or ejaculatory ducts is identified and found not to be amenable to surgical reconstruction (simultaneous VE with transurethral resection of the ejaculatory ducts or scrotal vasoepididymostomy with inguinal vasovasostomy is usually unsuccessful). The hemitransected vas can be reapproximated in two layers using interrupted 10-0 and 9-0 microsutures.

Identification of the Appropriate Epididymal Tubule

Selection of the correct epididymal tubule location for anastomosis is not a random event. Epididymal tubule diameter increases gradually from caput to cauda. Anastomosing to a larger tubule may result in higher patency rate and the more distal along the epididymis, the higher the pregnancy rate. Once vasoepididymostomy is selected as the optimal reconstruction technique (with patent abdominal vas and sufficient vasal length), the testis is delivered within the tunica vaginalis outside of the wound. A longitudinal incision is made on the anterior aspect of the tunica vaginalis. With long-term epididymal obstruction, a small hydrocele is commonly observed upon opening the tunica vaginalis. The epididymis is then inspected under the operating microscope at 15× to 25× magnification to select an anastomotic site (just proximal to the site of suspected obstruction). Often, a discrete line of demarcation is noted, proximal to which (closer to the testicle) there are dilated epididymal tubules, and distal to which (toward the vas) the epididymis is soft with collapsed tubules.

If the level of obstruction in the epididymis is not clearly demarcated, choose a tubule distally and puncture it with a 10-0 needle to aspirate epididymal fluid and examine it microscopically. If sperm or abundant sperm parts are not found, proceed in an identical fashion proximally in the direction of the caput. Once sperm are identified, the puncture may be sealed with bipolar cautery, and the anastomosis may be performed several millimeters proximally along the epididymal tubule.

Preparation of the Epididymal Tubule and Vas Approximation

The epididymal tunic covering the tubule is thick and tough. By contrast, the bare epididymal tubule underneath is thin and delicate, and caution should be taken to avoid accidental puncturing, resulting in leakage of epididymal fluid and collapse of the tubule. Once a potential epididymal tubule for the anastomosis is identified, a relatively avascular, straight area of the epididymal tunica is grasped with sharp jeweler’s forceps and tented upward (Fig. 52.34A). A 3- to 4-mm buttonhole is made in the tunica with microscissors to create a round opening that approximates the outer diameter of the prepared vas deferens (Figs. 52.34 and 52.35). Because microsutures are to be placed longitudinally in the tubule, a straight tubule segment is preferable to one that is curved. This allows needle bites running further along the tubule and ultimately a longer incision to be made longitudinally between the two needles.

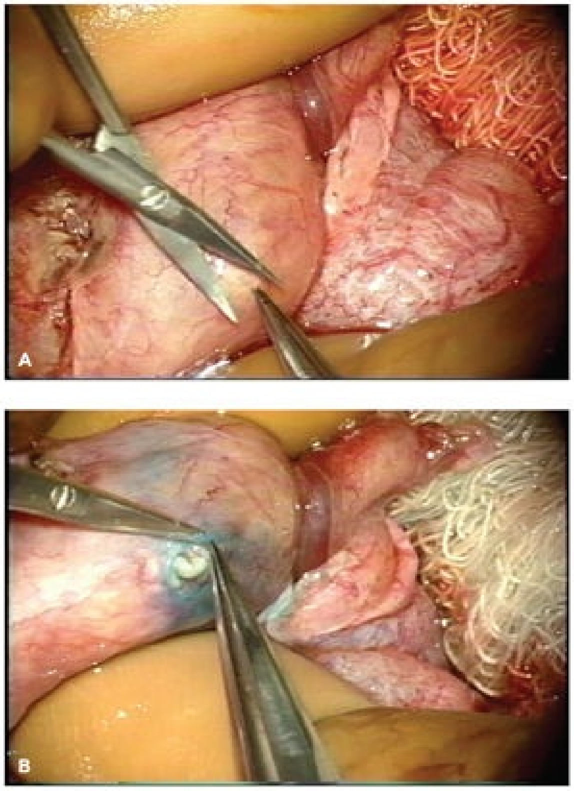

FIGURE 52.34 **A:** Once a potential epididymal tubule for the anastomosis is identified, a relatively avascular, straight area of the epididymal tunica is grasped with sharp jeweler's forceps and tented upward. **B:** A 3- to 4-mm buttonhole is made in the tunica with microscissors to form a round opening that approximates the outer diameter of the prepared vas deferens.

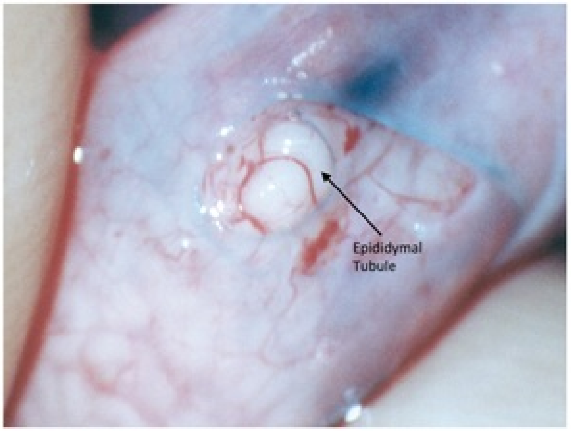

FIGURE 52.35 Epididymal tunic is precisely removed overlying selected epididymal tubule based on appearance which indicates an area below the obstruction.

After the initial cut on the epididymal tunic, there is often a thin layer of residual tunic covering the epididymal tubule. Use of indigo carmine on the tissue may enhance visualization of this overlying tunic (Fig. 52.34B). The residual tunica should be dissected off completely using sharp and blunt dissection to expose the bare epididymal tubule underneath and to facilitate its intussusception into the vasal lumen when completing the anastomosis.

The vas deferens is drawn up through an opening in the tunica vaginalis and secured in proximity to the anastomotic site with two to four interrupted 6-0 polypropylene sutures placed through the vasal adventitia and the tunica vaginalis. Care should be taken to avoid taking too deep a bite with the suture because this may result in accidental occlusion of the vasal lumen and failed surgery. The vasal lumen should reach the opening in the epididymal tunica easily, with length to spare (Fig. 52.36). To avoid tension or kinking of the vas, the surgeon should inspect the position and orientation of the vas when the testicle is delivered outside as well as when the testicle is replaced in its natural orientation into the scrotum. The posterior edge of the epididymal tunica is then approximated to the posterior edge of the vas muscularis and adventitia with two or three interrupted sutures of 9-0 nylon (see Fig. 52.36). This brings the vasal lumen in close approximation to the epididymal tubule selected for anastomosis. Adequate hemostasis of the vas and the epididymal tunic is essential, as the fluid in the epididymis cannot dissolve blood clot, which would be disastrous to the anastomosis.

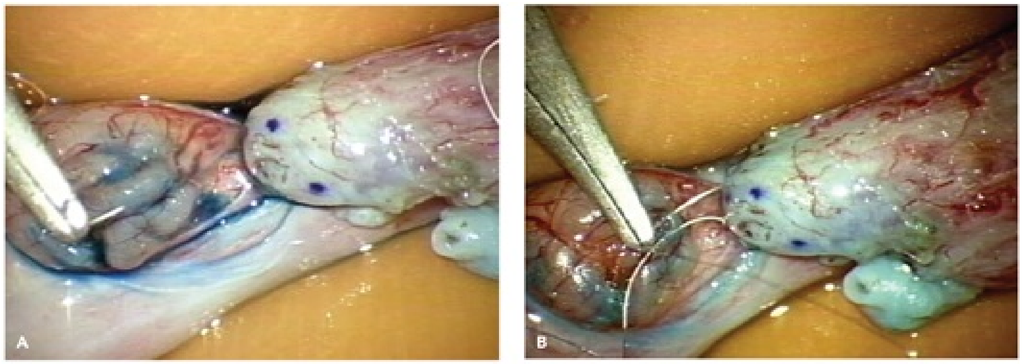

FIGURE 52.36 A: In preparation for vasoepididymostomy, the vas is secured on the edge of the tunica epididymis with two or three 9-0 sutures with its lumen opposing the midportion of the isolated epididymal tubule, prepared for placement of first of the double-armed 10-0 mucosal sutures in longitudinal fashion on the tubule. B: Placement of the second double-armed 10-0 mucosal sutures in a longitudinal fashion on the tubule.

Longitudinal Intussusception Vasoepididymostomy

The LIVE procedure is our preferred technique for microsurgical vasoepididymostomy, providing the highest patency rate among the various alternative techniques (39–41,51). To facilitate even distribution of the suture points, four microdots are placed with a microtip marking pen on the vasal ends to demarcate the exit points of the four suture needles to be placed in the vas (in a similar manner to the 6 microdot technique for vasovasostomy) (see Fig. 52.36). For the anastomosis, 1-inch monofilament 10-0 double-armed nylon sutures with 70-micron-diameter taper-point needles are used. Double-armed sutures allow inside-out placement of the needles on the mucosa, eliminating the need for manipulation of the mucosa and the possibility of back walling (see Figs. 52.39 to 52.41, see LIVE details).

As described, the vas is secured with 9-0 nylon sutures at the edge of the epididymal tunica opening, with the vasal lumen positioned at the center of the selected epididymal tubule. Under the highest magnification of the operating microscope (25× to 40×), the needles of two double-armed 10-0 microsutures are placed longitudinally on the epididymal tubule (Figs. 52.36 and 52.37). The microneedles should remain in the epididymal tubule until it is incised longitudinally. Because the diameter of the needle (70 microns) is significantly larger than the suture diameter (17 microns), pulling the needle through earlier will result in epididymal fluid leakage. Collapse of the epididymal tubule, along with impaired visibility from cloudy epididymal fluid, hinders visibility to make a precise opening in the tubule for the anastomosis or to place an additional suture if required.

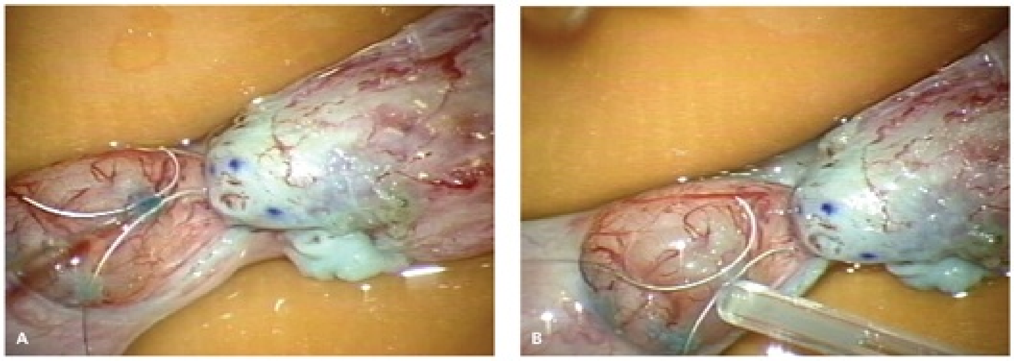

FIGURE 52.37 A: Two double-armed 10-0 mucosal sutures placed in longitudinal fashion on the tubule. B: Following initial placement, a longitudinal incision is made between the needles.

Using a 15-degree ophthalmic knife, the tubule is incised longitudinally between the two needles of the 10-0 sutures (Figs. 52.37B and 52.38). Epididymal fluid is then aspirated with a 5-microliter micropipette or with a 24-gauge angiocatheter connected to a syringe (see Fig. 52.37B). The fluid is examined for sperm under light microscopy intraoperatively.

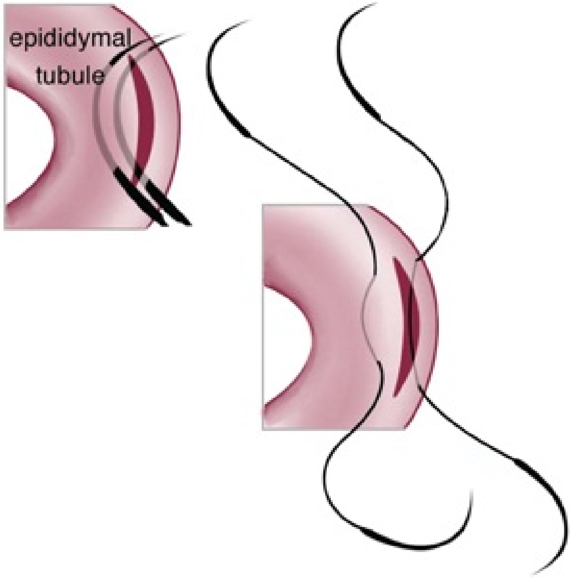

FIGURE 52.38 Following the incision made between the two needles (each from one double-armed suture), needles are subsequently pulled through.

If motile sperm are identified, cryopreservation of the sample should be considered for future use with ICSI if the anastomosis fails. Generally, if the level of the epididymal tubule is carefully selected, the fluid inside is likely to contain sperm or sperm parts. Absence of abundant sperm or sperm parts in the fluid indicates that obstruction is still proximal to the selected tubule segment. The anastomosis should be set up in the same manner as described at a more proximal site (closer to caput), and the same algorithm should be followed.

Following identification, suture placement, and incision of an optimal epididymal tubule, the needles of the two double-armed 10-0 sutures are then gently pulled through and placed to the vasal mucosa in an inside-out fashion through the four microdots (Fig. 52.39). Needle placement varies depending on whether the selected epididymal tubule for the anastomosis lies parallel (see Fig. 52.39) or perpendicular (Fig. 52.40) to the vas.

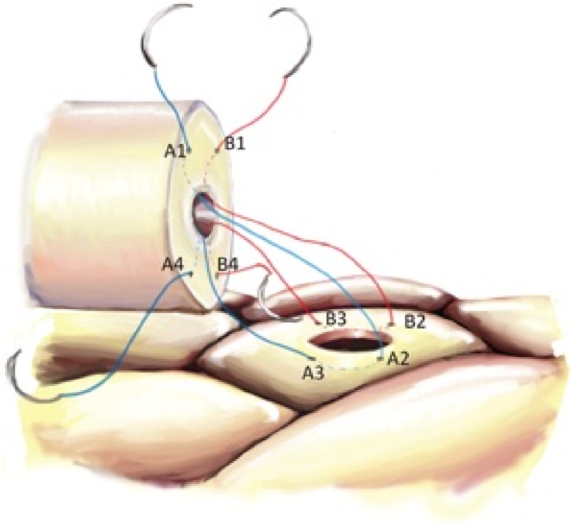

FIGURE 52.39 LIVE when the epididymal tubule lies parallel to the vasal lumen. Two-needle intussusception vasoepididymostomy. This technique allows the use of two double-armed sutures to provide a 4-point fixation on the vasal end for the anastomosis. 1: After pulling through the 10-0 mucosal sutures from the epididymal tubules, they are placed in inside-out fashion on the vasal end according to the plan for tying at the four denoted positions (*A1* and *A4* for one stitch; *B1* and *B4* for second stitch). 2: A 9-0 tension-reducing suture is placed to position the vasal lumen in direct opposition with the epididymal lumen prior to tying the mucosal sutures. Mucosal sutures are then tied to their own ends (suture end at *A1* tied to suture end at *A4*; suture end at *B1* tied to suture end at *B4*) to complete the anastomosis. 3: Ten to 12 9-0 sutures are placed on the vasal sheath and the tunica epididymis to complete the outer layer of the anastomosis.

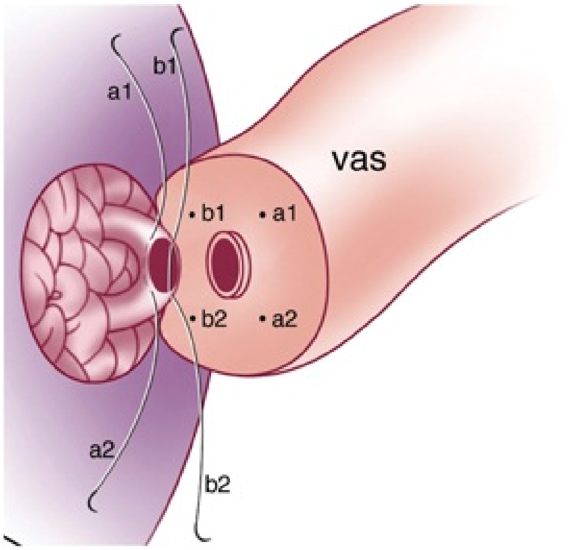

FIGURE 52.40 Placement of a double-armed microsuture for LIVE when the epididymal tubule is perpendicular to the vasal lumen. The numbers indicate suture placement. When the epididymal tubule is aligned perpendicular with the vasal lumen, each mucosal suture can be cross-tied with the end of the other mucosal suture (*a1* to *b1* and *a2* to *b2*) to complete the anastomosis.

Vasoepididymostomy: Completing the Anastomosis

To avoid tearing the 10-0 sutures out of the epididymal tubule during tying, it is essential to set up the vas to allow the vasal and epididymal lumina to be in direct apposition to each other. This is achieved by placing a 9-0 tension-reducing suture approximating the epididymal tunic to the vasal sheath prior to tying the 10-0 microsutures. This 9-0 suture is tied loosely to allow visualization of the anastomosis during tying of the 10-0 sutures. Just prior to tying, the ends of each of the 10-0 sutures should be gently pulled until the opposite end just begins to move. This prevents incorporation of a loose loop of excess suture into the anastomosis and ensures that the epididymal mucosa is plastered against the vasal mucosa prior to tying. When setting up the anastomosis, in order to achieve the lowest tension possible without kinking the vas, the vasal lumen usually may end up lying parallel (see Fig. 52.39) or perpendicular (see Fig. 52.40) to the direction of the epididymal tubule depending on anatomy. The ends of sutures for tying should be chosen carefully according to the orientation of the vas with respect to the direction of the epididymal tubule. In the setting when the vas and the epididymal tubules are parallel to each other, the two sutures are tied with their own ends on either side of the stay suture (see Fig. 52.39). By not tying until the free end moves, this assumes that the epididymal tubule is plastered against the inside of the vasal lumen. In the setting when the vas and the epididymal tubules are perpendicular to each other, it is not necessary to push the ends of the 10-0 sutures on the same side of the 9-0 tension-reducing suture to tie. Instead, the two 10-0 sutures can simply be cross-tied to each other. Modification of the LIVE technique for the use of a single-armed suture is feasible (Fig. 52.41, see "Technique" section). Finally, we recommend placing 10 to 12 interrupted sutures of 9-0 nylon for the outer layer closure approximating the vasal outer muscularis and adventitia to the cut edge of the epididymal tunica (Fig. 52.42). Care should be taken to avoid injury to the peripheral epididymal tubules during the placement of needles on the epididymal tunic.

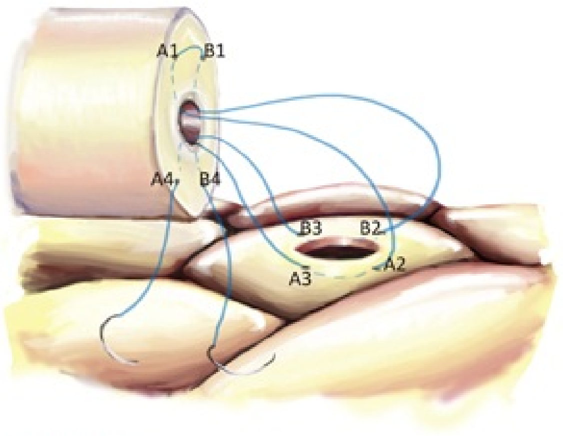

FIGURE 52.41 Placement of single long double-armed microsuture for LIVE when the epididymal tubule is parallel to the vasal lumen. The numbers indicate the placement of the first bites (1 and 2) of the two needles when the surgeon is right-handed.

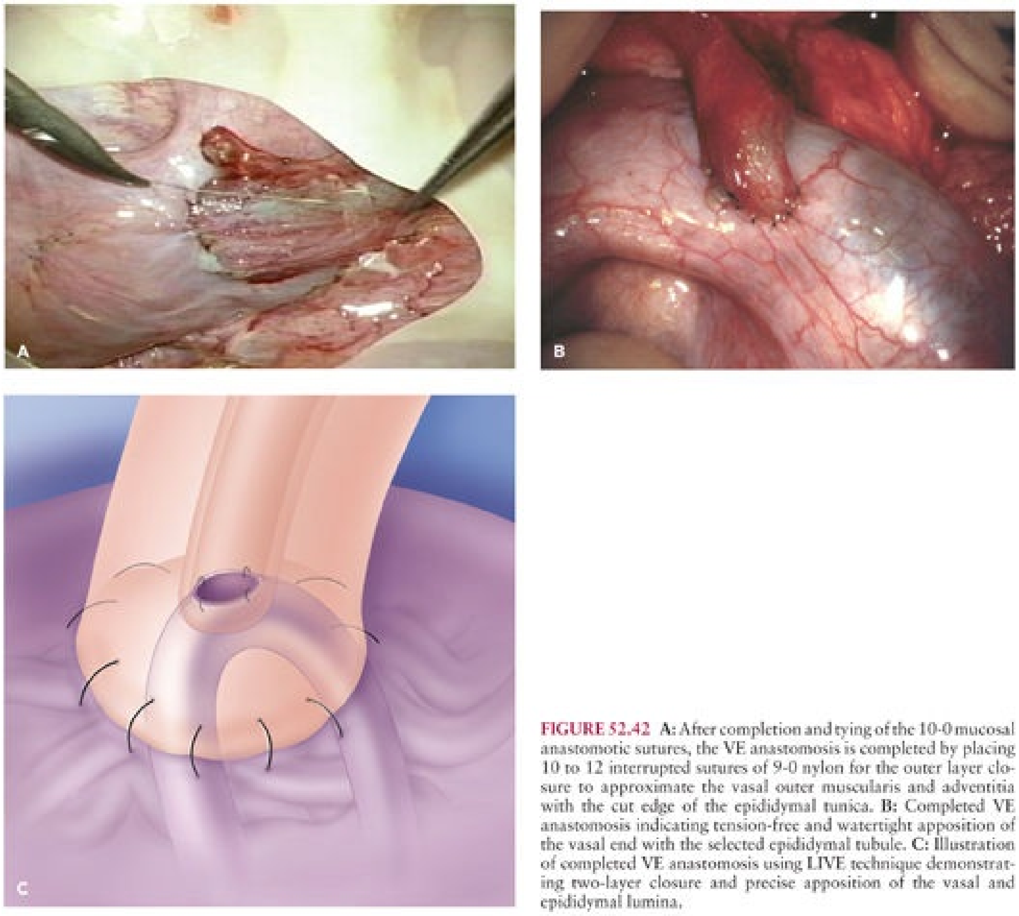

FIGURE 52.42 **A:** After completion and tying of the 10-0 mucosal anastomotic sutures, the VE anastomosis is completed by placing 10 to 12 interrupted sutures of 9-0 nylon for the outer layer closure to approximate the vasal outer muscularis and adventitia with the cut edge of the epididymal tunica. **B:** Completed VE anastomosis indicating tension-free and watertight apposition of the vasal end with the selected epididymal tubule. **C:** Illustration of completed VE anastomosis using LIVE technique demonstrating two-layer closure and precise apposition of the vasal and epididymal lumina.

Closure

After careful hemostasis and copious irrigation of the tissue, the tunica vaginalis should be closed with absorbable sutures and the testis returned intrascrotally in the correct orientation. The remaining closure is completed as for vasovasostomy. Care should be taken to avoid any tension when manipulating the testis and spermatic cord after the delicate anastomosis is completed. With careful control of hemostasis, the risk of scrotal edema or hematoma can be minimized and drainage is generally not necessary.

Maneuvers to Gain Extra Length to Bridge a Larger Gap

As mentioned in vasovasostomy technique, the simplest maneuver to gain length to bridge a larger gap for the anastomosis is mobilization of the abdominal vas superiorly toward the external inguinal ring. The skin incision may be extended toward the external inguinal ring. Care should be taken to avoid stripping the periadventitial sheath, which would compromise the vasal blood supply. When length of the vas deferens remains insufficient, the cauda and corpus epididymis can be dissected off the testis (from VE junction to the caput) and flipped up to obtain additional length without tension (see Fig. 52.14B). The full depth of the epididymis is encircled with a small Penrose drain at the level of obstruction and, under 8× to 16× magnification, it is dissected distally off the testis, yielding sufficient length to perform the anastomosis (10). Usually, a surgical plane can be developed between the epididymis and testis, and injury to the epididymal blood supply can be minimized by staying directly on the tunica albuginea of the testis. The inferior and, if necessary, the middle epididymal branches of the testicular artery are doubly ligated and divided to free an adequate length of epididymis. The superior epididymal branches entering the epididymis at the caput must always be preserved and can provide adequate blood supply to the entire epididymis. The tunica vaginalis is then closed over the testis with absorbable suture, which prevents drying of the testis and thrombosis of the surface testicular vessels during the anastomosis. The dissected epididymis can remain outside the tunica vaginalis for the anastomosis.

Use of Single-Armed Microsutures for Longitudinal Intussusception Vasoepididymostomy

LIVE can be performed using 10-0 single-armed sutures, which are less costly than the double-armed sutures (52). The disadvantage is that two of the four needle placements on the vasal end have to be done with outside-in approach. Two 10-0 sutures are initially placed on the vas in an outside-in fashion. If the selected epididymal tubule lies perpendicularly to the vasal lumen, it is recommended to place the two needles on the two dots on the same side as the dominant hand of the surgeon. If the selected tubule lies in parallel to the vas, the sutures can be first placed on the two upper microdots and then pulled through the vasal lumen. Insertion of a 2- to 3-mm microvessel dilator during the outside-in placement of the needle may further decrease the risk of back walling the vasal lumen mucosa. The LIVE procedure can then be performed in a similar fashion, with two needles placed on the epididymal tubules where a longitudinal incision is made between the needles. The sutures are then pulled through and placed to the remaining two microdots marked on the vasal end in an inside-out fashion to complete the anastomosis. Tying of the two single-armed sutures can follow the same principle as described previously (53).

Use of Long Double-Armed Microsutures for Longitudinal Intussusception Vasoepididymostomy

LIVE can be performed using a single long (6-inch) double-armed microsuture (see Fig. 52.41). Similar to the use of single-armed microsutures, the disadvantage is that two of the four needle placements on the vasal end have to be completed in outside-in fashion. The two needles at each end are first placed in the vas in outside-in fashion. If the selected epididymal tubule lies perpendicularly to the vasal lumen, it is recommended to place the two needles on the two dots on the same side as the dominant hand of the surgeon. If the selected tubule lies in parallel to the vas, the suture needles can be first placed on the two upper microdots (A1, B1) and then pulled through the vasal lumen (see Fig. 52.41). Insertion of a 2- to 3-mm microvessel dilator during the outside-in placement of the needle may decrease the risk of back walling vasal lumen mucosa. The LIVE procedure can then be performed in a similar fashion, with the two needles next placed on the epididymal tubules (in at A2 and out at A3 for one suture end, and from B2 to B3 for other suture end) where a longitudinal incision is made between the needles. The sutures are then pulled through and placed to the remaining two microdots marked on the vasal end (A4 and B4, respectively) in an inside-out fashion to complete the anastomosis (see Fig. 52.41). Because a single double-armed suture is used in this case, suture tying (A4 to B4 suture ends) needs to be done only once. Care must be taken to ensure there is no loose loop of suture before tying, so that leakage of epididymal fluid does not occur.

Surgical Caveats

Errors can occur at several crucial points of the surgery, requiring the anastomosis to be performed more proximally. Examples may include absence of sperm or sperm parts in the epididymal fluid, tearing of the epididymal tubule, or breakage of a mucosal suture. In any of these cases, a new position more proximally in the epididymis should be identified to redo the anastomosis. The surgeon should not become frustrated when it is necessary to redo the setup at a more proximal site (toward the caput epididymis). Although it is time-consuming to redo an anastomosis, the extra time is crucial. Vasoepididymostomy is a delicate operation where the outcome is highly dependent on technical perfection.

Postoperative Care and Follow-up

Postoperative care is identical to vasovasostomy. During the postoperative period, patients are advised to use an ice pack intermittently for 48 hours and to avoid strenuous activity and sexual intercourse for 3 weeks (to minimize the risks of disruption of the anastomosis due to the force of propulsion of the excurrent ductal system from orgasm). Scrotal support is recommended for 6 weeks to prevent hematoma and edema.

Postoperative semen analyses may be performed at 1, 3, and 6 months and every 6 months thereafter. Patients who have motile sperm return to the ejaculate should consider cryopreserving sperm, as initially patent anastomoses may eventually shut down. From our experience with the LIVE technique, the majority of patients who have a patent anastomosis will have sperm in the ejaculate in the first 6 months. Early patency was achieved in 73% of subjects at 4 to 6 weeks postoperatively with median best sperm count 12.9×10^6 per mL and 23% forward motility (54). Reports of sperm return to the ejaculate document that this could take up to 1 to 2 years following vasoepididymostomy including all techniques (55,56). However, it is rare for patients who have been persistently azoospermic in the first 6 months postoperatively to develop patency of anastomoses. The late “shutdown” rate, defined as the percentage of subjects who had sperm postoperatively but later became persistently azoospermic, was 4% at 1 year postoperatively in our patients. Persistently azoospermic men without cryopreserved sperm can select redo vasoepididymostomy or surgical sperm retrieval by various techniques combined with ICSI to achieve pregnancy with their partner (22).

Complications

Potential surgical complications associated with vasoepididymostomy are similar to vasovasostomy and include wound infection, scrotal edema, hematoma, orchalgia, and persistent epididymal obstruction (surgical failure). Most of these complications can be managed conservatively. More devastating complications such as ischemic epididymal fibrosis and testicular atrophy may be encountered rarely. The risk of complications increases with multiple previous unsuccessful reconstruction attempts, with significant tissue fibrosis from prior surgery (57), or in cases where additional dissection is required to mobilize the vas or the epididymis to bridge a larger gap for anastomosis.

Outcomes

Results

Preoperative and postoperative nomograms which account for age, testis volume, obstructive interval, prior reversal, reconstruction type, sperm granuloma, and intraoperative fluid quality have identified that testicular volume and obstructive interval are the factors that most significantly affect patency outcomes following vasectomy reversal (44). One of the largest published series by the Vasovasostomy Study Group demonstrated a patency rate of 86% and a pregnancy rate of 52% (20). In our published series of 194 consecutive cases, patency was achieved in 99.5% of vasovasostomy cases when sperm were found in the vasal fluid on at least one side intraoperatively (7). The pregnancy rate in the first 100 cases was 54%, which increased to 64% when female factor infertility was excluded. The LIVE technique, our preferred vasoepididymostomy approach, has resulted in improved vasoepididymostomy patency (90%, literature range 31% to 92%) and pregnancy (40%, literature range 10% to 50%) rates in both animal and human studies (see Fig. 52.39) (51,54,58,59). Numerous groups in addition to ours have subsequently demonstrated excellent LIVE technique results also for idiopathic obstructive azoospermia (60). Robotic-assisted LIVE has also been described (26,58).

It is established that type of reconstruction, duration of obstruction, type of fluid found in the vas deferens, and presence of sperm, particularly motile sperm (55), during reconstruction can affect procedure success (12,20). The requirement for vasoepididymostomy is predicted by postvasectomy obstructive interval and sperm granuloma (61). Pregnancy rates were 82% to 89% for obstructive intervals of 0 to 15 years but significantly lower, 44%, with obstructive intervals more than 15 years (12). Persistent azoospermia beyond 6 months after vasovasostomy and beyond 12 months after vasoepididymostomy is an indication of likely immediate surgical failure. Late failure approximately 14 months after initial patency was observed in 12% of men after vasovasostomy and in 21% after vasoepididymostomy (56). Late failure is usually preceded by progressive loss of motility on semen analyses, followed by decreasing sperm counts (56). Because of the possibility for late stricture formation, we recommend cryopreservation of semen specimens when motile sperm are found in the ejaculate. Failure of vasectomy reversal may be due to unrecognized epididymal obstruction and compromised anastomosis, among other causes. With patency and pregnancy rates of 67% and 30%, respectively, repeat vasectomy reversal surgery remains a viable option (57). Prognostic factors for successful initial vasectomy reversal also apply to repeat procedures.

Cost-Benefit Analyses

The decision for microsurgical reconstruction versus sperm retrieval options is complex, based on a multitude of factors including number of children desired, surgical history, prior fertility, maternal age, financial resources, microsurgeon experience, and religious beliefs. To address the comparison between microsurgical reconstruction and assisted reproductive technique (ART), several cost-benefit analyses have been conducted. Our institution has reported a cost per delivery after vasectomy reversal of $25,475 with a delivery rate of 47%, whereas the cost per delivery after sperm retrieval and ICSI was $72,521 with a delivery rate after one cycle of ART with sperm retrieval of 33% (8). Furthermore, a systematic review of four cost-benefit analyses comparing these two approaches also reported outcomes in favor of vasectomy reversal surgery for vasal and epididymal obstruction (62). Another study described the cost of MESA with ICSI/IVF to be nearly 2.5 times higher than vasectomy reversal, even in men with prior failed vasectomy reversal, in addition to the costs associated with multiple births and increased risk of birth defects (9,49,63).

Vasovasostomy and vasoepididymostomy are safe and cost-effective management options for postvasectomy infertility. Although the average interval to motile sperm in the ejaculate is 2.1 and 5.8 months, respectively, and average interval until pregnancy after successful microsurgical reconstruction is 16 months, microsurgical reconstruction has significant advantages over ART including that the normal partner avoids treatment and subsequent children are possible without the need for further intervention (56). The ASRM Guidelines recommend microsurgical reconstruction if the obstructive interval following vasectomy is less than 15 years and no female fertility risk factors are present (64). The use of ICSI with sperm retrieval is recommended with advanced female age (>37 years of age) or female fertility factors requiring IVF (i.e., tubal disease), if the chance for success is greater with this technique, or if the couple prefers this method for financial or other justification (64).

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CHAPTER 53 MICROSURGICAL VARICOCELECTOMY

MARC GOLDSTEIN

Varicocele is by far the most commonly performed operation for the treatment of male infertility. Varicocele is found in approximately 15% of the general population, 35% of men with primary infertility, and in 75% to 81% of men with secondary infertility (1,2). Animal and human studies have demonstrated that varicocele is associated with a progressive and duration dependent decline in testicular function (1–9).

Repair of varicocele will halt any further damage to testicular function (5,6) and in a large percentage of men result in improved spermatogenesis (10–12) as well as enhanced Leydig cell function (13,14). The potentially important role of urologists in preventing future infertility and/or androgen deficiency underscores the importance of using a varicocelectomy technique that minimizes the risk of complications and recurrence.

DIAGNOSIS

Varicoceles are defined as dilations of the veins of the testicular pampiniform plexus, which are believed to be caused by absent or incompetent valves in the internal spermatic veins. The diagnosis of a clinically significant varicocele is generally made on physical examination of the scrotum and its contents. The patient is examined in the supine and standing position with the scrotum warmed first with a heating pad. This promotes relaxation of the scrotal dartos muscle and facilitates accurate evaluation for varicocele. The scrotum should be inspected carefully for any easily visible dilated veins. The spermatic cord should be palpated between thumb and forefinger for palpable tortuous veins. Both spermatic cords should be palpated while the patient performs a Valsalva maneuver in the upright position.

Varicoceles are graded I through III using the system outlined in Table 53.1. Grade I varicoceles are small, grade II moderate, and grade III large. Varicoceles should collapse in the supine position. If the varicocele remains prominent with the patient supine, this finding suggests a mechanical obstruction to testicular venous outflow from a retroperitoneal mass (sarcoma, lymphoma, or a renal tumor with venous thrombus). An abdominal ultrasound or computerized tomography scan should be obtained to evaluate the retroperitoneum in these men.

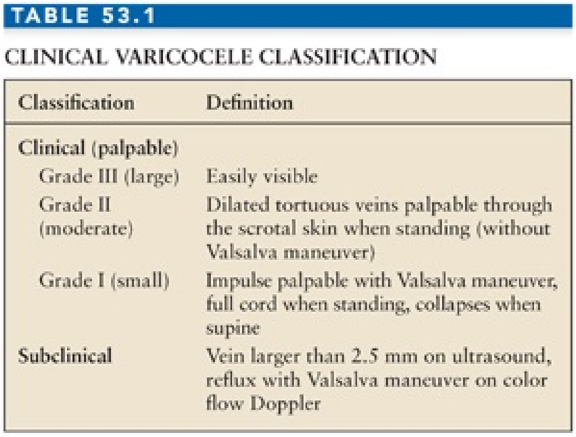

TABLE 53.1

CLINICAL VARICOCELE CLASSIFICATION

Classification	Definition
Clinical (palpable)	
Grade III (large)	Easily visible
Grade II (moderate)	Dilated tortuous veins palpable through the scrotal skin when standing (without Valsalva maneuver)
Grade I (small)	Impulse palpable with Valsalva maneuver, full cord when standing, collapses when supine
Subclinical	Vein larger than 2.5 mm on ultrasound, reflux with Valsalva maneuver on color flow Doppler

Scrotal ultrasonography with color flow Doppler imaging with the patient upright and supine may prove useful in equivocal cases or in patients with a body habitus that makes accurate physical examination of the scrotum impossible. Using ultrasonography, the diameter of the internal spermatic vein can be measured and retrograde flow through the vein during Valsalva maneuver documented. Veins that are greater than 3.5 mm can generally be detected on physical exam. Those that are 2.5 mm or less are usually not palpable and have been termed *subclinical* varicoceles (15). The need for diagnosing and treating subclinical varicoceles is controversial (16). Recent studies have indicated that repair of subclinical varicoceles is of questionable value (17). However, other reports have indicated that repair of small palpable or subclinical right varicoceles may be beneficial if present in conjunction with a larger left-sided varicocele (18–20).

A recent meta-analysis by Marmar et al. (12) clearly shows a significant increase in pregnancy rates after microsurgical varicocelectomy.

INDICATIONS

The indications for repairing varicoceles in adolescents include the following:

1. Palpable (especially grade III) left varicocele with associated ipsilateral testicular atrophy (with the volume of the left testis being at least 20% less than that of the right)
2. Palpable (especially grade III) varicocele with abnormal semen analysis results
3. Large (grade III) symptomatic (painful) varicocele
4. Bilaterally palpable varicocele with testicular atrophy

Although prophylactic treatment of adolescent varicocele for the prevention of future infertility and androgen deficiency is controversial, the author feels that it is much easier to prevent future infertility and androgen deficiency than to treat it once it has occurred. In view of the high success rate and low morbidity of microsurgical repair, the author feels that repair of grade III varicoceles is the conservative therapy since it conserves testicular function.

Based on the Best Practice Policies for Male Infertility of the American Urological Association (21), varicocele treatment should be offered to the male partner of a couple attempting to conceive when all of the following are present:

> A varicocele is palpable.
> The male partner has one or more abnormal semen parameters or sperm function test results.
> The couple has documented infertility.
> The female partner has normal fertility or potentially correctable infertility.

In addition, testicular pain associated with varicocele (in the absence of other pathology), psychological concern regarding future fertility, and cosmetic reasons are all relative indications. Varicocele repair is not indicated in men with normal semen analysis, sperm function assays, or only a subclinical (nonpalpable) varicocele.

ALTERNATIVE THERAPY

Several approaches exist for varicocelectomy, including retroperitoneal and inguinal open techniques, microsurgical inguinal and subinguinal approaches, laparoscopic repairs, and radiographic embolization. The microsurgical varicocelectomy, low inguinal (22) or subinguinal, as first described by Marmar et al. (23), is preferred because it is associated with higher success rates and lower morbidity and recurrences than nonmicrosurgical techniques (22,24).

Microsurgical Inguinal and Subinguinal Operations: The Preferred Approaches

Subinguinal varicocelectomy is currently the most popular approach. It has the advantage of allowing the spermatic cord structures to be pulled up and out of the wound so that the testicular artery, lymphatics, and small periarterial veins may be more easily identified. In addition, an inguinal or subinguinal approach allows access to the external spermatic and even gubernacular veins (25), which may bypass the spermatic cord and result in recurrence if not ligated. Lastly, an inguinal or subinguinal approach allows access to the testis for biopsy or examination of the epididymis for obstruction or repair of hydrocele (26).

Anesthesia

If the testis is delivered, as described in the following text, regional or light general anesthesia is preferred. If only the cord is delivered, local anesthesia with a 50/50 combination of 0.25% bupivacaine and 1% lidocaine is satisfactory with adjunctive intravenous heavy sedation. After infiltration of the skin and subcutaneous tissues, the cord is infiltrated prior to delivery. Blind cord block carries with it a small risk of inadvertent testicular artery injury (27). A 30-gauge needle should therefore be employed for cord block to minimize the risk of injury and hematoma.

Inguinal and Subinguinal Approaches

The introduction of the subinguinal approach, just below the external inguinal ring (23), obviates the necessity for opening any fascial layer and is associated with less pain and a rapid recovery comparable to laparoscopic procedures. At the subinguinal level, however, significantly more veins are encountered; the artery is more often surrounded by a network of tiny veins which must be ligated and the testicular artery has often divided into two or three branches, making arterial identification and preservation more difficult (28).

Subinguinally, the arterial pulsations are often dampened by compression on the edge of the external ring, making its identification somewhat more difficult than when the external oblique is opened. Table 53.2 summarizes the criteria for performing the operation inguinally (external oblique opened) versus subinguinally (fascia intact). In general, it is best to use a subinguinal approach in men with a history of any prior inguinal surgery. Under these circumstances, the cord is usually stuck to the undersurface of the external oblique and opening the fascia risks injury to the cord. A subinguinal approach is easier in obese men in whom opening and closing the fascia is difficult through a small incision. A subinguinal approach is easier in men with high, lax, capacious external rings and in men with long cords and low-lying testes. In these men, the level of the external ring is fairly proximal to the testis and opening the fascia will not result in a significant diminution in the number of veins to be ligated or in the branching of the testicular artery.

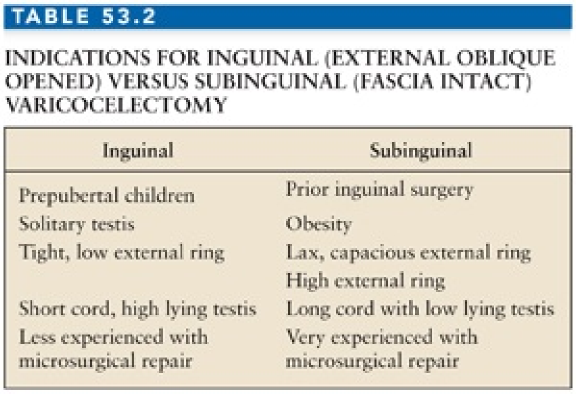

TABLE 53.2

INDICATIONS FOR INGUINAL (EXTERNAL OBLIQUE OPENED) VERSUS SUBINGUINAL (FASCIA INTACT) VARICOCELECTOMY

Inguinal	Subinguinal
Prepubertal children	Prior inguinal surgery
Solitary testis	Obesity
Tight, low external ring	Lax, capacious external ring
	High external ring
Short cord, high lying testis	Long cord with low lying testis
Less experienced with microsurgical repair	Very experienced with microsurgical repair

I recommend always opening the external oblique in prepubertal children without prior inguinal surgery. In children, the testicular artery is very small and systemic blood pressure is low, making identification of the artery very difficult in a subinguinal approach. The fascia could also be opened in men with a solitary testis in whom preservation of the artery is critical. Exposure of the cord more proximally (at the inguinal level) allows identification of the artery before it has branched, where clear pulsations are more readily observed.

Consider opening the fascia in men with prior failed subinguinal varicocelectomy in order to dissect proximal to the prior scarred ligation area. The microdissection will be quicker and easier. A subinguinal operation is significantly more difficult than a high inguinal operation and should only be used by surgeons who perform the operation frequently. Less experienced microsurgeons should start out doing inguinal operations because it is easier. An inguinal operation is employed when simultaneous ipsilateral hernia repair is performed.

Before making the incision, the location of the external inguinal ring is determined by invagination of the scrotal skin and is marked. The size of the incision is determined by the size of the testis when delivery of the testis (see in the following text) is planned. Atrophic testes can be delivered through a 2- to 2.5-cm incision. Larger testes require a 3-cm incision. The incision is made within Langer lines to minimize scarring.

If the decision is made to perform an inguinal operation and thus to open the fascia, the incision is begun at the external ring and extended laterally 2 to 3.5 cm along Langer lines (Fig. 53.1). If the operation is to be performed subinguinally, the incision is placed in the skin folds right over the external ring (Fig. 53.2).

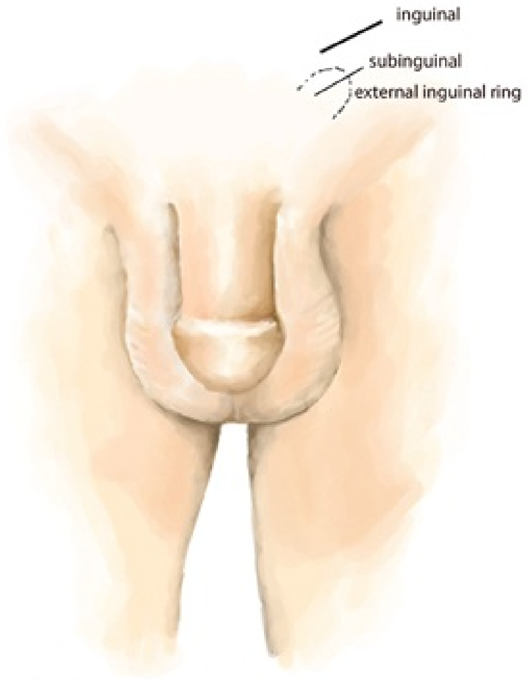

FIGURE 53.1 Subinguinally, a 2- to 3.0-cm incision is placed in the skin folds right over the external inguinal ring. Inguinally, a 3.5- to 4-cm incision is begun at the external ring and extended laterally along Langer lines.

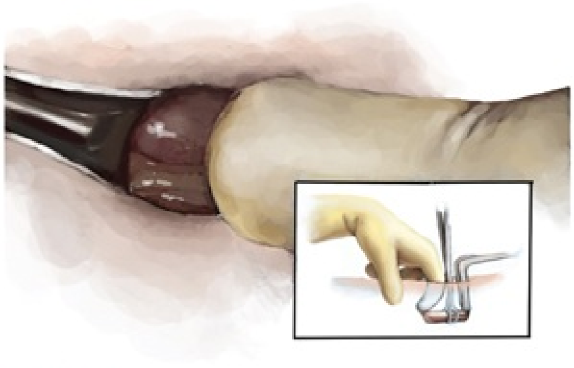

FIGURE 53.2 The index finger is then hooked under the external inguinal ring, retracting it cephalad. A small Richardson retractor is slid along the back of the index finger and retracted caudad over the cord toward the scrotum.

Camper fascia and Scarpa fascia are divided with the electrocautery between the blades of a Crile clamp. The superficial epigastric artery and vein, if encountered, are retracted or alternately, may be clamped, divided, and ligated. If an inguinal approach is selected, the external oblique aponeurosis is cleaned and opened the length of the incision to the external inguinal ring in the direction of its fibers. A 3-0 absorbable suture placed at the apex of the external oblique incision facilitates later closure.

The spermatic cord is grasped with a Babcock clamp and delivered through the wound. The ilioinguinal and genital branches of the genitofemoral nerve are excluded from the cord which is then surrounded with a large Penrose drain. If a subinguinal incision was made, Camper and Scarpa fascia are incised as described previously. An index finger is introduced into, around and along, the cord as it passes into the scrotum. The index finger is then hooked under the external inguinal ring, retracting it cephalad. A small Richardson retractor is slid along the back of the index finger and retracted caudad over the cord toward the scrotum (see Fig. 53.2). The spermatic cord will be revealed between the index finger and retractor. The assistant grasps the cord with a Babcock clamp and delivers it through the wound. The cord is surrounded with a large Penrose drain.

Dissection of the Cord

The operating microscope is then brought into the field. Under 6× to 10× power magnification, the external spermatic fascia is opened with a Bovie electrocautery in the direction of the cremasteric fibers in order to avoid injury to the cremasteric arteries. A 5-0 Vicryl suture is placed at the apex of the opening to facilitate later closure. The relatively avascular internal spermatic fascia is opened with scissors as high as possible and held open with the straight mosquito forceps (Fig. 53.3). The magnification is increased from 10× to 25× power, and after irrigation with 1% papaverine solution, the cord is inspected for the presence of pulsations revealing the location of the testicular artery. A micro-Doppler is extremely useful in identifying arteries (Fig. 53.4). Once the testicular artery is identified, it is dissected free of all surrounding tissue, tiny veins, and lymphatics using a fine-tipped nonlocking microneedle holder and microforceps. The artery is encircled with a vessel loop for positive identification and gentle retraction (Fig. 53.5). The suspected artery is tested by elevating the artery with the tips of the microneedle holder until it is completely occluded and then slowly lowering it until a pulsating blush of blood appears just over the needle holder. If the artery is not immediately identified, the cord is carefully dissected beginning with the largest veins. The veins are stripped clean of adherent lymphatics (Fig. 53.6) and the underside of the largest veins inspected for an adherent artery. In approximately 50% of cases, the testicular artery is adherent to the undersurface of a large vein (29). All veins within the cord, with the exception of the vasal veins, are doubly ligated with either hemoclips (Fig. 53.7A) or by passing two 4-0 silk ligatures, one black and one white, beneath the vein (Fig. 53.7B). These are then tied and the vein divided. Medium hemoclips are used for veins 5 mm or larger, small auto-hemoclips for veins 1 to 5 mm and 4-0 silk for veins smaller than 2 mm. The use of an automatic clip applier (LigaClip, small size, Ethicon, Somerville, New Jersey) significantly reduces operating time. The bipolar cautery can be used for veins smaller than 0.5 mm. The vasal veins are preserved, providing venous return. If the vas deferens is accompanied by dilated veins greater than 2.5 mm in diameter, they are dissected free of the vasal artery and ligated. The vas deferens is always accompanied by two sets of vessels. As long as at least one set of deferential veins remains intact, venous return will be adequate. At the completion of the dissection, the cord is run over the index finger and inspected to verify that all veins have been identified and ligated. Small veins adherent to the testicular artery are dissected free and ligated, or, if smaller than 1 mm, cauterized using a bipolar unit with a jewelers' forceps tip and divided. Cremasteric arteries are found (usually between and adherent of two cremasteric veins) and preserved in at least 90% of cases. Recent studies employing power Doppler in men with nonobstructive azoospermia undergoing testicular sperm extraction have found that tubules containing sperm are most likely to be found in areas of the testis with the greatest blood supply. Therefore, logic would dictate that preservation of maximum testicular blood supply, including both testicular and cremasteric arteries, would be beneficial to testicular function. At the completion of the dissection, only the testicular arteries, cremasteric arteries, lymphatics, and vas deferens with its vessels remain (Fig. 53.8). Dissection is not deemed complete until a run through the cord reveals no additional internal or external spermatic veins. Each time a vein is found and ligated, any remaining veins will dilate up.

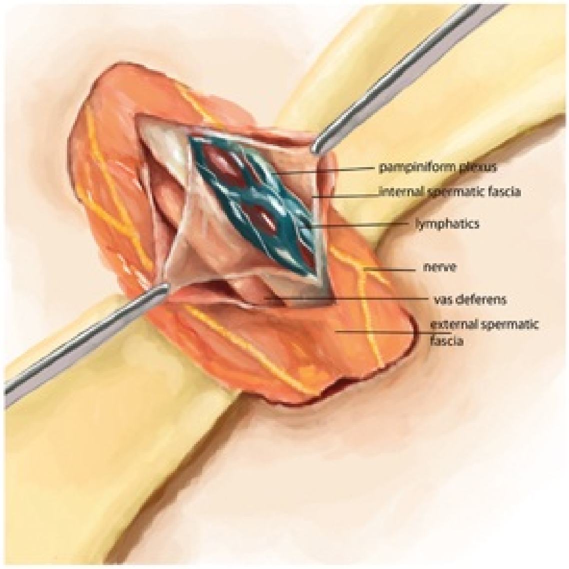

FIGURE 53.3 The relatively avascular internal spermatic fascia is opened with scissors as high as possible and held open with the straight mosquito forceps.

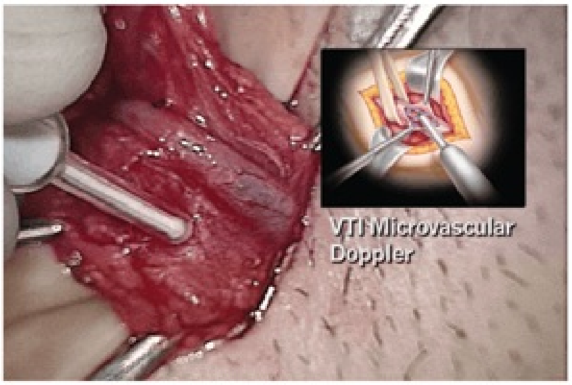

FIGURE 53.4 A micro-Doppler is extremely useful in identifying arteries.

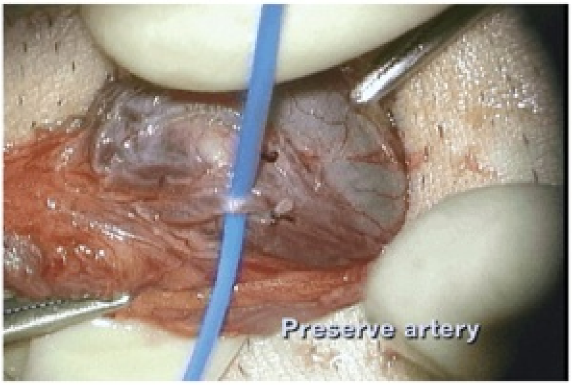

FIGURE 53.5 The artery is encircled with a vessel loop for positive identification and gentle retraction.

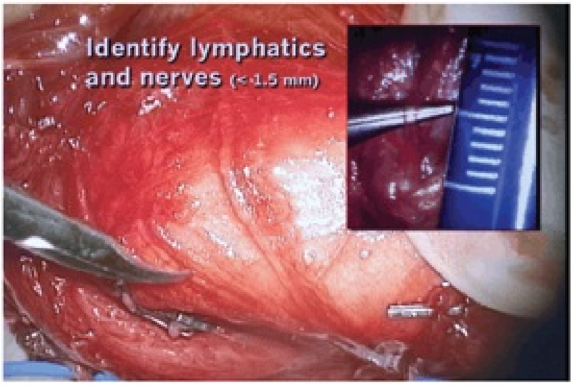

FIGURE 53.6 The veins are stripped clean of adherent lymphatics.

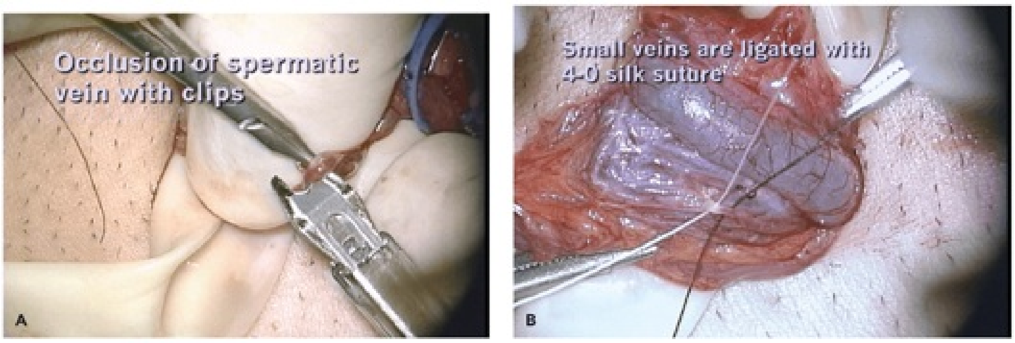
Occlusion of spermatic vein with clips
A
Small veins are ligated with 4-0 silk suture
B

FIGURE 53.7 All veins within the cord, with the exception of the vasal veins, are doubly ligated with either hemoclips (**A**) or by passing two 4-0 silk ligatures, one black and one white beneath the vein (**B**).

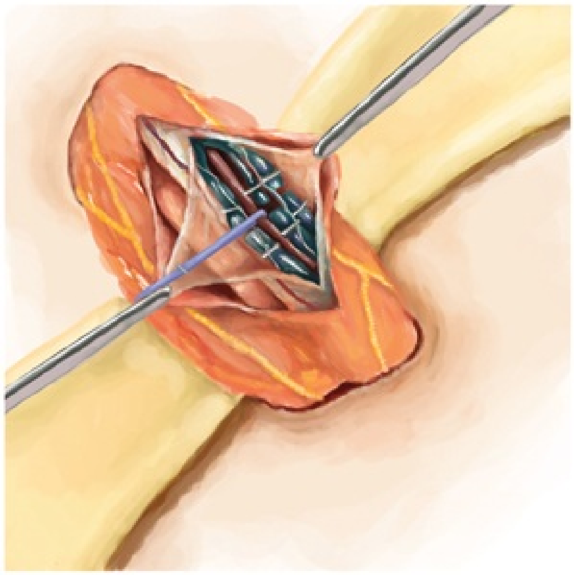

FIGURE 53.8 Only the testicular arteries, cremasteric arteries, lymphatics, and vas deferens within its vessels remain.

Delivery of the Testis

Delivery of the testis through a small inguinal or subinguinal incision guarantees direct visual access to all possible avenues of testicular venous drainage. Delivery of only the cord allows access to most external spermatic collaterals but may miss those close to the testis and will not allow access to scrotal or gubernacular collaterals which have been demonstrated radiographically to be the cause of 10% of recurrent varicoceles (25). With gentle upward traction on the cord and upward pressure on the testis through the invaginated scrotum, the testis is easily delivered through the wound. All external spermatic veins are identified and double ligated with hemoclips and divided (Fig. 53.9). The gubernaculum is inspected for the presence of veins exiting from the tunica vaginalis. These are either cauterized or doubly clipped and divided. When this step is completed, all testicular venous return must be within the Penrose surrounded cord.

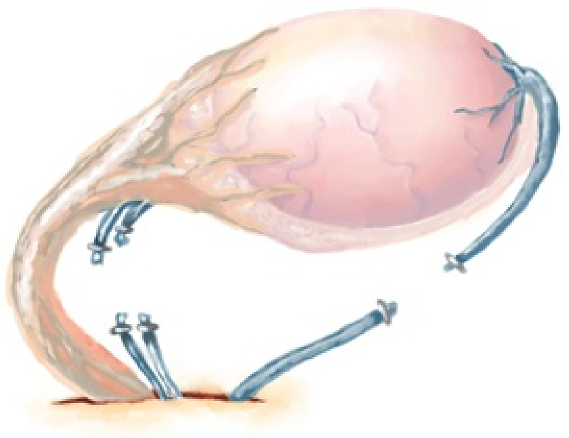

FIGURE 53.9 All external spermatic and gubernacular veins not within the Penrose are identified and doubly ligated or clipped and divided.

Hydroceles are found in 15% of testes associated with varicoceles. As little as 3 mL of hydrocele fluid can significantly alter testicular temperature regulation (30). If a hydrocele is noted when the testis is delivered, it is repaired. Small ones may be treated with excision of a segment of the hydrocele sac and cauterization of the edges. Larger hydroceles are treated with either a bottleneck or microsurgical excision technique (26,31). The temporary high venous pressure immediately after varicocelectomy can make good hemostasis difficult to achieve after excisional hydrocelectomy. Therefore, there should be no hesitation to employ a scrotal Penrose drain placed in the dependent portion of the scrotum for 24 hours after combined varicocelectomy and excisional hydrocelectomy. The testis is then returned to the scrotum and the Penrose drain is left beneath the cord structures. Grabbing the previously placed 5-0 Vicryl left at the apex of the opening, the spermatic fascia is closed with 2 to 3 interrupted sutures of 5-0 Vicryl (Fig. 53.10). This covers the testicular artery ligation area.

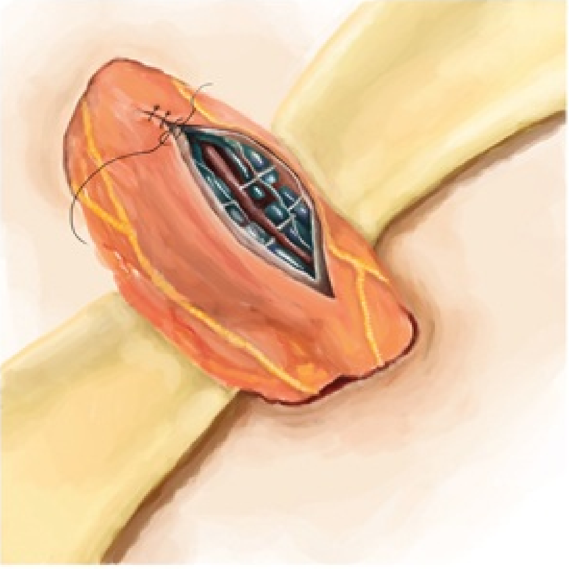

FIGURE 53.10 The spermatic fascia is closed with interrupted sutures of 5-0 Vicryl.

The external oblique aponeurosis, if opened, is reapproximated with continuous suturing using the previously placed 3-0 suture. Scarpa fascia and Camper fascia are reapproximated with a 5-0 monofilament absorbable subcuticular suture reinforced by two to three Steri-Strips (Fig. 53.11). A scrotal supporter is applied and stuffed with fluff-type dressings. The patient is discharged on the day of surgery with a prescription for Tylenol with codeine. Light work may be resumed in 2 or 3 days.

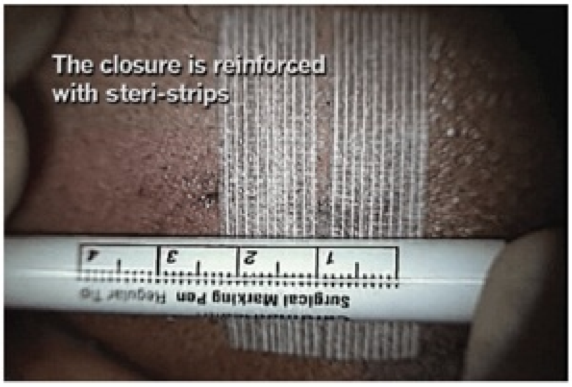
The closure is reinforced with steri-strips
4
3
2
1
Surgical Marking Pen Regular Tip

FIGURE 53.11 Scarpa fascia and Camper fascia are reapproximated with a 5-0 monofilament absorbable subcuticular suture and reinforced by two to three Steri-Strips.

If any large external or gubernacular veins are ligated after delivery of the testis, the cord is again run over the index finger to search for veins that may dilate after gubernacular or external veins are ligated. The external spermatic fascia is closed with interrupted 5-0 Vicryl, facilitated by the previously placed suture at the apex of the external spermatic fascia.

Radiographic Occlusion Techniques

Radiographic coil occlusion of the internal spermatic veins has been successfully employed for varicoceles (32–34). These techniques are performed under a local anesthetic through a small cutdown incision over the femoral vein. The recurrence rate after balloon occlusion was originally 11% and more recently is reported as low as 4% (25,35–37). Failure to successfully cannulate small collaterals and external spermatic veins and scrotal collaterals results in recurrence. Venographic placement of a balloon or coil in the internal spermatic vein is successfully accomplished in 75% to 90% of attempts (38–41); therefore, a significant number of men undergoing attempted radiographic occlusion will ultimately require a surgical approach. In addition, the radiographic techniques take between 1 and 3 hours to perform compared to 25 to 45 minutes required for surgical repair. Although rare, serious complications of radiographic balloon or coil occlusion have included migration of the balloon or coil into the renal vein, resulting in loss of a kidney, pulmonary embolization of the coil or balloon (36), femoral vein perforation or thrombosis, and anaphylactic reaction to radiographic contrast medium. Antegrade scrotal sclerotherapy via cannulation of a scrotal vein has been employed in Europe (42–44). The recurrence rate is similar to balloon or coil techniques. Long-term follow-up is not available, and the consequence of escape of the sclerosing agent into the renal vein and vena cava is unknown. In addition, the larger the varicocele, the higher the failure and recurrence rate with this technique. We have seen many men referred with late (2 to 5 years) recurrence after radiographic occlusion. They typically present as slow-filling veins that become prominent at the end of the day. Initial cursory physical examination can miss these recurrences. We believe these recurrences are likely due to recanalization through the coils because, unlike surgical repair, the veins are not ligated and divided. Although often initially successful, I believe that radiographic occlusion is less durable than microsurgical ligation.

COMPLICATIONS OF VARICOCELECTOMY

Hydrocele

Hydrocele formation is the most common complication reported after non-microscopic varicocelectomy. The incidence of this complication varies from 3% to 33%, with an average incidence of about 7%. Analysis of the protein concentration of hydrocele fluid indicates that hydrocele formation after varicocelectomy is due to lymphatic obstruction (45). At least half of post-varicocelectomy hydroceles grow to a size large enough to warrant surgical excision due to the discomfort and growth of the hydrocele to a large size. The effect of hydrocele formation on sperm function and fertility is uncertain. It is known that men with varicocele have significantly elevated intratesticular temperatures (46,47), and this appears to be an important pathophysiology phenomenon mediating the adverse effects of varicocele on fertility (48). The development of a large hydrocele creates an abnormal insulating layer that surrounds the testis. This may impair the efficiency of the countercurrent heat exchange mechanism and therefore obviate some of the benefits of varicocelectomy (30).

Use of magnification to identify and preserve lymphatics can virtually eliminate the risk of hydrocele formation after varicocelectomy (22,49,50). The management of post-varicocelectomy hydrocele is identical to that for other hydroceles (see Chapter 54).

Testicular Artery Injury

The diameter of the testicular artery in humans is 1.0 to 1.5 mm. The testicular artery supplies two-thirds of the testicular blood supply and the vasal and cremasteric arteries the remaining one-third (51). Microdissections of the human spermatic cord have revealed that the testicular artery is closely adherent to a large internal spermatic vein in 40% of men. In another 20% of men, the testicular artery is surrounded by a network of tiny veins (29). During the course of cord dissection for varicocelectomy, the artery may go into spasm and even in its unconstructed state is often difficult to positively identify and preserve. Injury or ligation of the testicular artery carries with it the risk of testicular atrophy and/or impaired spermatogenesis. Starzl’s transplant group (52) reported a 14%

incidence of frank testicular atrophy when the testicular artery was purposely ligated. The actual incidence of testicular artery ligation during varicocelectomy is unknown, but some studies suggest it is common (53). Animal studies indicate that the risk of testicular atrophy after testicular artery ligation varies from 20% to 100% (27,54). In humans, atrophy after artery ligation is probably less likely due to the contribution of the cremasteric as well as vasal arterial supply (51). In children, the potential for neovascularization and compensatory hypertrophy of the vasal and cremasteric vessels is probably greater than in adults, making atrophy after testicular artery ligation less likely. Use of magnifying loupes, or preferably an operating microscope and/or a fine-tipped Doppler probe, facilitates identification and preservation of the testicular artery and therefore minimizes the risk of testicular injury. Radiographic balloon or coil occlusion techniques also eliminate this risk.

Varicocele Recurrence

The incidence of varicocele recurrence following surgical repair varies from 0.6% to 45% (24,55–57). Recurrence is more common after repair of pediatric varicoceles. Radiographic studies of recurrent varicoceles visualize periarterial, parallel inguinal, or midretroperitoneal collaterals or, more rarely, transscrotal collaterals (25). Retroperitoneal operations miss parallel inguinal and scrotal collaterals. Nonmagnified inguinal operations have a lower incidence of varicocele recurrence but fail to address the issue of scrotal collaterals or small veins surrounding the testicular artery. The microsurgical approach with delivery of the testis lowers the incidence of varicocele recurrence to less than 1% compared to 9% using conventional inguinal techniques (22,50).

RESULTS

Varicocelectomy results in significant improvement in semen analysis in 60% to 80% of men. Reported pregnancy rates after varicocelectomy vary from 20% to 60% (12). A randomized controlled trial of surgery versus no surgery in infertile men with varicoceles revealed a pregnancy rate of 44% at 1 year in the surgery group versus 10% in the control group (58). In our series of 1,500 microsurgical operations, 43% of couples were pregnant at 1 year (59) and 69% at 2 years when couples with female factors were excluded. Microsurgical varicocelectomy results in return of sperm to the ejaculate in up to 50% of azoospermic men with palpable varicoceles (60–64).

The results of varicocelectomy are also related to the size of the varicocele. Repair of large varicoceles results in a significantly greater improvement in semen quality than repair of small varicoceles (17,65). In addition, large varicoceles are associated with greater preoperative impairment of semen quality than small varicoceles, and consequently, overall pregnancy rates are similar regardless of varicocele size. Some evidence suggests that the younger the patient is at the time of varicocele repair, the greater the improvement after repair and the more likely the testis is to recover from varicocele-induced injury (66). Varicocele recurrence, testicular artery ligation, or post-varicocelectomy hydrocele formation are often associated with poor postoperative results. In infertile men with low serum testosterone levels, microsurgical varicocelectomy alone results in substantial improvement in serum testosterone levels (13,14,66–68).

SUMMARY

Varicocele is an extremely common entity present in 15% of the male population. Varicoceles are found in approximately 35% of men with primary infertility but 75% to 81% of men with secondary infertility. Mounting evidence clearly demonstrates that varicocele causes progressive duration-dependent injury to the testis. Larger varicoceles appear to cause more damage than small varicoceles and, conversely, repair of large varicoceles results in greater improvement of semen quality. Varicocelectomy can halt the progressive duration-dependent decline in semen quality found in men with varicoceles. The earlier the age at which varicocele is repaired, the more likely is recovery of spermatogenic function. Varicocelectomy can also improve Leydig cell function resulting in increased testosterone levels (59,66,67).

The most common complications after varicocelectomy are hydrocele formation, testicular artery injury, and varicocele persistence or recurrence. The incidence of these complications can be reduced by employing microsurgical techniques, inguinal or subinguinal operations, and exposure of the external spermatic and scrotal veins. Employment of these advanced techniques of varicocelectomy provide a safe, effective approach to elimination of varicocele, preservation of testicular function, and, in a substantial number of men, an increase in semen quality and likelihood of pregnancy as well as increase in serum testosterone in men with androgen deficiency.

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CHAPTER 54 EPIDIDYMECTOMY

KHALID ALRABEEAH AND PETER CHAN

With the advances in medical imaging to evaluate the nature of most scrotal masses along with the availability of broad-spectrum antimicrobials to control infection of scrotal organs, surgical removal of all or part of the epididymis is done infrequently. Nonetheless, when conservative management fails, epididymectomy, although invasive with potential risks of ultimately requiring an orchiectomy and compromising fertility, can be effective in managing defined epididymal pathologies or chronic scrotal pain in carefully selected patients. Because complete and partial epididymectomy is infrequently performed, most urologists have variable levels of experience in these procedures. This further highlights the importance of having a thorough understanding of the various issues related to epididymectomy ranging from preoperative counseling to anatomic details to the variation of surgical techniques so that in the rare event that calls for such a procedure, one can aim not only to minimize any potential complications and risks of compromising the fertility status of the patients but also to maximize long-term satisfaction of the patients particularly in relation to chronic scrotal pain control.

INDICATIONS

The indications of epididymectomy include scrotal pain localized to the epididymis (e.g., postvasectomy), chronic epididymitis, painful large/complex epididymal cystic disease, trauma, tuberculous epididymitis, and schistosomal epididymitis. Epididymectomy for other less common epididymal pathologies such as benign epididymal adenoma, sarcoidosis, and epididymal malignancies (primary and metastatic) have also been described in the literature. Postvasectomy scrotal pain, chronic epididymitis, and painful epididymal cysts or spermatoceles are the most common indications for epididymectomy (Table 54.1), as shown by a series of recent studies on epididymectomy (1–13).

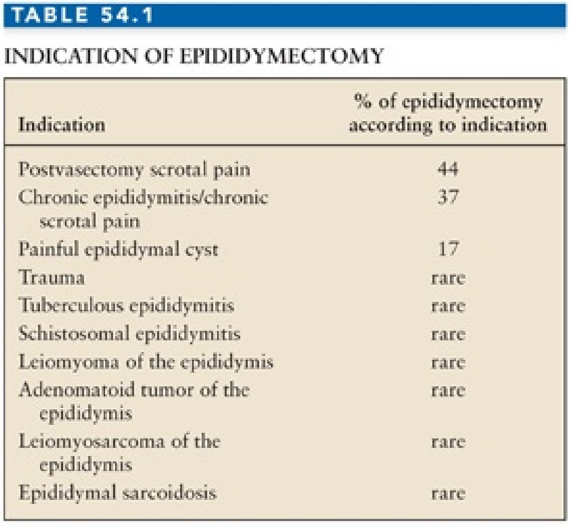

TABLE 54.1

INDICATION OF EPIDIDYMECTOMY

Indication	% of epididymectomy according to indication
Postvasectomy scrotal pain	44
Chronic epididymitis/chronic scrotal pain	37
Painful epididymal cyst	17
Trauma	rare
Tuberculous epididymitis	rare
Schistosomal epididymitis	rare
Leiomyoma of the epididymis	rare
Adenomatoid tumor of the epididymis	rare
Leiomyosarcoma of the epididymis	rare
Epididymal sarcoidosis	rare

COUNSELING ISSUES

Patients with chronic scrotal pain syndrome are challenging to manage. No single treatment modality can guarantee effective alleviation of the pain; hence, the logic is to begin with conservative treatment such as reassurance, warm, local compresses, sitz baths, scrotal supports, massotherapy, exercise, and relaxation followed by medical treatments ranging from analgesic, anti-inflammatory, antibiotics, antioxidants, anxiolytic, alpha-blockers, anticholinergics to narcotics, and neuroleptic drugs. Additional adjunctive treatments with physiotherapy, biofeedback, psychotherapy, regional anesthesia, and acupuncture may also be considered. Invasive and irreversible treatment such as surgery should only be considered as the last resort and the patients should always be informed, in addition to any potential complications, that the pain may not be fully relieved and may even worsen. Thus, just like any patients suffering from chronic pain such as chronic pelvic pain syndrome, men with chronic scrotal pain syndrome are best managed with a multidisciplinary approach involving, in addition to urologists, general surgeons, pain specialists/anesthetists, psychologists, sexologists, physiotherapists, infectious disease specialists, radiologists, reproductive medicine specialists, and acupuncturists.

Proper preoperative counseling for invasive surgery such as epididymectomy in the absence of clear epididymal pathologies such as solid or cystic mass, chronic inflammation, or infection is particularly important. Although epididymectomy is usually performed unilaterally, the surgeon must disclose its potential negative impact on fertility, particularly if there is any indication on history and physical examination that suggests impaired testicular function or the integrity of the excurrent ductal system on the contralateral testis. In the case of partial epididymectomy for resection of localized epididymal lesion, simultaneous microsurgical vasoepididymostomy should be offered in an attempt to maximize the quantity of sperm in semen for preservation of fertility. Likewise, sperm banking by cryopreservation prior to surgery, the potential needs of simultaneous surgical sperm extraction for use with in vitro fertilization/intracytoplasmic sperm injection in the future should also be part of the discussion and preoperative counseling in addition to surgical risks and complications.

Chronic pain is a common presentation in men undergoing epididymectomy and can have a significant psychosocial impact on the individual’s quality of life. At the same time, chronic scrotal pain can also be caused by psychosocial factors, making surgical management or medications such as anti-inflammatory and analgesics ineffective in relieving the pain. As in patient with chronic orchialgia undergoing surgical denervation procedure, we advocate for all patients requiring epididymectomy specifically for chronic pain to undergo multiple sessions of nerve block with local anesthesia or “sham nerve block” with a small amount (<1 mL) of saline to the spermatic cord (with the patient blinded). If pain persists despite properly performed nerve block, surgery with denervation or epididymectomy may not adequately resolve the pain postoperatively. On the other hand, if the pain resolves with a sham nerve block, then psychosomatic factor may play a significant role in the etiology of the chronic pain in the subject. We feel that this information can help surgeon inform patients to have a realistic expectation of the outcomes of surgery. Men with pain and tenderness clearly and specifically localized to the epididymis are the best candidates for epididymectomy.

SURGICAL TECHNIQUES

Anatomic Consideration

Detailed knowledge of epididymal anatomy is essential before undertaking surgery of this delicate structure. The epididymis is blessed with a rich blood supply derived from the testicular vessels superiorly and the deferential vessels inferiorly. With this extensive interconnections between these branches, either the testicular or the deferential branches (but not both) to the epididymis may be divided without compromising epididymal viability. This is particularly important when performing partial epididymectomy (see the following text). Another important piece of anatomic details of the blood supply of the epididymis is that because the epididymal branches of the testicular artery are medial to and separate from the main testicular artery and veins, epididymectomy may be performed on the epididymis without compromising testicular blood supply.

Interestingly, anatomic studies using immunohistochemistry indicated that innervation of the epididymis is denser than that of testis (14). Indeed, there is an extensive sympathetic nerve network innervating the cauda epididymis and vas deferens (15) controlled by the abdominal and pelvic sympathetic nervous system to generate transport of spermatozoa from the epididymis through the vas deferens. Human epididymis is densely innervated by nerve fibers immunoreactive to a wide range of neuropeptides including tyrosine hydroxylase, neuropeptide Y, vasoactive intestinal polypeptide, calcitonin gene-related peptide, galanin, peptide histidine isoleucine, and substance P (14). Besides regulation of smooth musculature function, some of these neuropeptides (most notably substance P and calcitonin gene-related peptide) have been shown to take part in the processing of pain (16,17).

A recent histologic study reported a reproducible, distinct anatomic distribution of nerves in the spermatic cord that is commonly found to have pathologic condition such as wallerian degeneration in men with chronic orchialgia. In decreasing order of nerve density, the three primary sites of this trifecta nerve complex are localized in (a) cremasteric muscle fibers, (b) perivasal tissues and vasal sheath, and (c) posterior cord lipomatous/perivessel tissues (18). Targeting these specific abnormal nerves may enhance the efficacy of pain control during surgical denervation or epididymectomy in patients with chronic orchialgia.

In human, distal caput, corpus, and cauda epididymis is a single, tightly coiled, 5- to 7-m long tubule. When refractory chronic pain due to obstruction of the outflow of the excurrent ductal system (such as postvasectomy) can be localized to a specific area such as cauda epididymis, partial epididymectomy may alleviate the pain. However, one must keep in mind that effectively, the surgery allows the point of obstruction to be migrated more proximally along the epididymis and there is a potential risk that similar pain may recur proximally. Even with complete epididymectomy for chronic pain due to obstruction, there is a risk that obstruction and pressure may build up postoperatively at the level of the testis leading to chronic orchialgia. Thus, prior to undertaking epididymectomy for pain control, the patient must receive proper counseling of the potential risks of recurrence of ipsilateral chronic pain.

Anesthesia

Simple epididymectomy can be completed within 1 hour, thus the choices of anesthesia including general, regional, and, in motivated patient, local anesthesia are all reasonable options. However, in complicated cases such as those with extensive inflammation that may require complicated dissection or if additional procedures such as microsurgical reconstruction with vasoepididymostomy and/or epididymal or testicular sperm retrieval are planned with a partial epididymectomy, general or long-acting regional anesthesia is preferred.

After induction of appropriate anesthesia, intravenous administration of antimicrobial drugs should be considered in cases when infectious causes of epididymitis are suspected.

Incision

For unilateral epididymectomy due to chronic pain secondary to inflammatory/infectious or obstructive causes, an ipsilateral transverse or midline scrotal incision can be used. A high scrotal incision should be considered if there is extensive inflammation that may require dissection and resection of the vas deferens in the subinguinal region or if a simultaneous vasoepididymostomy is planned during a partial epididymectomy. These incisions can also be used in most cases when the indication of epididymectomy is epididymal mass, as the great majority of these masses are benign adenomatoid tumors. However, when there is a history of rapid growth of an epididymal mass that is solid and hypervascular on sonography, the lesion may represent malignant epididymal tumor. In these extremely rare cases, an inguinal incision, as in radical orchiectomy for testicular tumor, should be used to allow early control of the spermatic cord and associated vasculature and lymphatics.

When scrotal incision is used, it should be large enough to allow delivery of the testis and epididymis. The tunica vaginalis can be exposed by developing the plane between it and the dartos muscle layers with a combination of sharp and blunt dissection. The use of electrocautery can provide excellent hemostasis. Alternatively, after the skin incision, some surgeons advocate to gather the successive layers with a suture placed at either end or in an Allis clamps to facilitate wound closure at the end of the procedure. In either approaches, one should attempt to deliver the intravaginal contents with the tunica vaginalis intact to allow for closure separate from the more superficial scrotal layers.

Handling of the Vas Deferens

Prior to opening the tunica vaginalis, in cases of inflammatory or infectious epididymitis, one should dissect superiorly along the spermatic cord toward the external inguinal ring to allow inspection for any sinus openings. If infectious epididymitis is suspected, appropriate culture of a swab of the operative field or any suspicious fluid should be performed followed by copious irrigation of the field. If the extent of inflammation involves more proximally along vas deferens and the spermatic cord, the incision may need to be extended or new incision made subinguinally to allow for adequate exposure for complete removal of inflammatory tissues. When epididymectomy is performed for postvasectomy pain, dissection along the spermatic cord should be performed to expose the vasectomy site to allow the testicular end of the vas deferens and any associated sperm granuloma to be resected.

In epididymectomy for other indications, the vas deferens may be divided and ligated at the junction of the convoluted and straight vas. This is particularly important if a partial epididymectomy for a benign focal lesion is planned and a simultaneous vasoepididymostomy is to be performed as it will allow the straight vas to be used for the vasoepididymostomy. Ligation of the vas can be done using absorbable sutures. Titanium clips should be avoided in patients with pain as the primary presentation.

In patient with pain as the chief complaint, microsurgical denervation can be considered simultaneously during epididymectomy. A formal denervation (see Chapter 54 on denervation) can achieve satisfactory results for pain alleviation but may inadvertently lead to decreased scrotal and penile skin sensation. Relief of chronic severe pain localized to the epididymis may be better achieved, in addition to epididymectomy, by denervating the perivasal nerve fibers (18) using a microbipolar forceps. Care should be taken during the procedure, as it may inadvertently damage the vas deferens.

The tunica vaginalis is opened to expose the epididymis. If extensive scarring from inflammation or infection has occurred, testis and epididymis may need to be dissected free from the visceral or inner side of the tunica vaginalis.

Partial Epididymectomy

When performing partial epididymectomy for localized benign lesions or cystic mass originated from the epididymis, opening of the tough overlying tunica epididymis may allow a surgical plane to be developed to allow clean isolation of the lesions from the vessels in the tunica and the rest of the epididymis. This maneuver is often overlooked even during simple spermatocelectomy and epididymal cyst removal. When the plane between the lesion and the epididymal tunica is properly developed, there should be minimal blood vessels on the surface of the lesion and the lesion can often be removed en bloc. Use of an operating microscope providing 6× to 25× magnification facilitates the dissection to allow preservation of the vasculature to minimize the risks of ischemic injury to the testis and the remaining epididymis and minimizes the risk of hematoma.

If fertility is desired and the contralateral testis is not functioning or absent, simultaneous vasoepididymostomy can be performed (see chapter for vasoepididymostomy) with the straight vas to an epididymal tubule proximal to the lesion. Microsurgical epididymal sperm aspiration (MESA) can be performed in conjunction particularly if preoperative semen cryopreservation failed to reveal adequate motile sperm. Extraction of testicular tissue for sperm cryopreservation (see chapter for micro TESE) may be needed if MESA fails to yield adequate motile sperm for cryopreservation.

When performing partial epididymectomy without concomitant vasoepididymostomy, attempt should be made to identify the outflow epididymal tubule for closure, which can be achieved with cauterization with microbipolar forceps with closure of the overlying epididymal tunica. This can minimize the formation of a sperm granuloma that may cause inflammatory pain in the future.

Complete Epididymectomy

After opening the tunica vaginalis, the divided testicular vas can be dissected back toward the cauda epididymis and removed with the epididymis en bloc. The convoluted vas is usually closely attached to the cauda epididymis. Separation of the convoluted vas and cauda epididymis is only necessary if one is attempting to preserve the convoluted vas. The epididymis can be divided from the testis with dissection beginning from the cauda portion (globus minor), reflected cephalically, and continued toward the caput epididymis (globus major). Alternatively, complete epididymectomy can begin at the caput and continue toward the cauda epididymis. The overlying tunica epididymis can be opened to allow separation of the epididymal tubules from the testis tunica albuginea. Dissection should begin in the lateral aspect of the epididymis, as the vasculature to the testis and epididymis generally lies in the medial aspect. Again, if infectious epididymitis is suspected, appropriate culture of a swab of the operative field or any purulent or suppurative exudate should be performed followed by copious irrigation and suction of the field.

Microsurgical technique with appropriate optical magnification is essential to preserve testicular blood supply. Dissection can be performed with a combination of sharp dissection using fine microscissors and blunt dissection and use of a microbipolar cautery forceps for hemostasis. Larger vessels should be ligated with sutures. One will encounter a variable anastomotic network of vasculatures from the vasal and testicular vessels. Although the vasculature associated with the cauda epididymis (from the vasal vasculature) will be sacrificed when removing the testicular end of the vas along with the epididymis, vessels encountered midway up during the dissection should be preserved as much as possible, as they originate from the main testicular vasculature entering cephalically. Although sometimes variable anatomically, the epididymal branches of the main testicular artery are usually encountered on the medial aspect on the plane of dissection in the corpus and caput epididymal regions and can be divided without compromising the testicular blood supply. The use of microsurgical technique, including use of a microbipolar cautery for hemostasis, is the key to allow maximal preservation of vasculature associated with the testis to avoid postoperative atrophy.

The attachment between caput epididymis and testis consists of a parallel bundle of efferent ductules, which can be ligated with absorbable suture and cauterized with a microbipolar to minimize the risks of sperm granuloma formation. Upon removal of the epididymis and the associated vas deferens, the epididymal bed should be irrigated. Appropriate antimicrobial drug may be used in cases suspicious of infectious epididymitis.

The epididymal bed should be carefully inspected under optical magnification to identify any significant bleeding to obtain hemostasis without compromising blood supply to the testis. In cases with extensive inflammation and suspicion of significant damage to the testicular blood supply, intraoperative sonogram with Doppler evaluation of the blood flow of the testicular parenchyma may help to confirm a healthy testicular vascular status.

Closure

If the tunica epididymis can be preserved, it should be reapproximated with running absorbable sutures to close the raw epididymal bed to minimize postoperative hematoma and leakage of testicular fluid from the efferent ductules. The tunica epididymis can also be approximated to the tunica albuginea of the testis but care should be taken to avoid suturing the testicular vessels subjacent to the tunica albuginea. Microsurgical technique and use of the microbipolar forceps will minimize the risk of such injury.

The tunica vaginalis is closed with absorbable sutures. In addition to copious irrigation, thorough inspection of the dartos and scrotal skin, preferably achieved with careful invagination, for any bleeding vessels for fulguration are the keys to minimize postoperative wound infection, scrotal abscess, and hematoma. The dartos layer and skin are closed with absorbable sutures. In infectious epididymitis, one may choose to use interrupted stitches to allow partial opening of the incision for drainage to prevent hematoma and postoperative scrotal abscess formation.

Although usually unnecessary, scrotal drainage is recommended in cases at risk for hematoma or scrotal abscess. Scrotal drainage can be accomplished by using a Penrose drain tunnelled through the dartos layer and the tunica vaginalis sac prior to completing their closure (with at least 10 cm in length intrascrotally to avoid slipping out). The drain should exit the scrotum through a new stab wound in a dependent area where it is secured to the scrotal skin with a 2-0 silk suture and safety pin. Side holes of the drain are unnecessary, as the tract occupied by the drain will allow fluid to exit to the dressing instead of accumulating intrascrotally. The drainage can be removed if no significant drainage is noted in the dressing after 24 to 48 hours.

Compression dressings to scrotum rarely holds effectively for more than an hour even when the patient is in bedrest. Surrounding the scrotum with fluff-type gauze held in place by a scrotal supporter with a hole cut out for the penis allows urination without removal of the supporter.

Special Considerations for Epididymal Malignancy

Although extremely rare, epididymectomy for malignancy requires a different approach. As mentioned previously, typical clues of an epididymal mass being malignant include finding of solid lesions on sonogram with hypervascularity and history of rapid growing in size. Besides adenocarcinoma, primary epididymal malignancies may include sarcoma, germ cell tumors, lymphoma, and plasmacytoma (19–23). In men with a known history of advanced malignancies such as prostate, kidney, and gastrointestinal tract, newly found solid, hypervascular growing mass in the epididymis may represent metastatic carcinoma (24–26).

In addition to the use of inguinal incision to deliver the testis and epididymis with the tunica vaginalis intact, the use of a modified Chevassu maneuver (27) to first isolate and cool with slush ice the operating field followed by temporary occlusion of the vasculature of the spermatic cord and gubernaculums can allow biopsy of the epididymal mass with intraoperative histologic evaluation of its frozen section for confirmation of malignancy. If malignancy is confirmed, radical epididymo-orchiectomy should be performed. Otherwise, epididymectomy may proceed as previously describe while sparing the testis.

OUTCOMES AND POSTOPERATIVE EVALUATIONS

Complications of epididymectomy include hematoma formation, orchitis, testicular injury, abscess formation, wound infection, persistent and recurrent chronic scrotal pain, and infertility. Inadvertent injury to testicular vasculature may lead to testicular hypotrophy or atrophy, which may contribute to hypogonadism if the contralateral testis is absent or atrophic.

Postoperatively, patients should be reevaluated at 2 to 6 months for improvement in pain. Physical examination to reevaluate the testicular size should be performed. If hypotrophy is suspected, scrotal sonography with vascular Doppler study may help to confirm any ischemic testicular injury. Serum testosterone and semen analyses are optional evaluations of testicular function that are indicated if there are signs or symptoms of new-onset hypogonadism or infertility.

RESULTS

Pain refractory to medical therapy remains the most common symptoms requiring epididymectomy. The results of postepididymectomy satisfaction in symptomatic relieve vary depending on the indications of surgery. In cases with postvasectomy scrotal pain and painful epididymal cysts, the overall reported satisfaction rate is around 85%. However, the overall satisfaction rate in patients with chronic epididymitis is lower (62%) (Tables 54.2 to 54.4) (1–13). In our unsystematic review of the current literature on epididymectomy, there appear to be some clinical factors that correlate or predict the success of pain relief postepididymectomy. For example, the presence of mechanical obstruction or localized tenderness to the epididymis seems to be a good predictor of long-term success in pain relief. On the contrary, a significantly lower percentage of patients with findings of chronic inflammatory changes in the epididymis, failure in relief of pain following spermatic cord block preoperatively, or pain radiating to the groin are less satisfied with postepididymectomy pain relief.

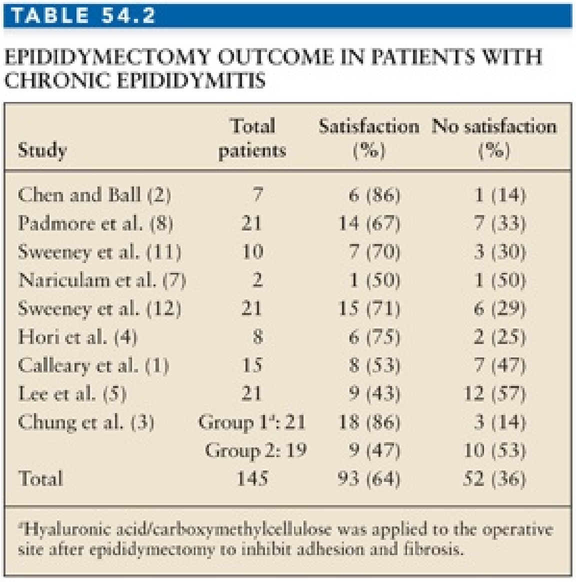

TABLE 54.2

EPIDIDYMECTOMY OUTCOME IN PATIENTS WITH CHRONIC EPIDIDYMITIS

Study	Total patients	Satisfaction (%)	No satisfaction (%)
Chen and Ball (2)	7	6 (86)	1 (14)
Padmore et al. (8)	21	14 (67)	7 (33)
Sweeney et al. (11)	10	7 (70)	3 (30)
Nariculam et al. (7)	2	1 (50)	1 (50)
Sweeney et al. (12)	21	15 (71)	6 (29)
Hori et al. (4)	8	6 (75)	2 (25)
Calleary et al. (1)	15	8 (53)	7 (47)
Lee et al. (5)	21	9 (43)	12 (57)
Chung et al. (3)	Group 1[a]: 21	18 (86)	3 (14)
	Group 2: 19	9 (47)	10 (53)
Total	145	93 (64)	52 (36)

[a] Hyaluronic acid/carboxymethylcellulose was applied to the operative site after epididymectomy to inhibit adhesion and fibrosis.

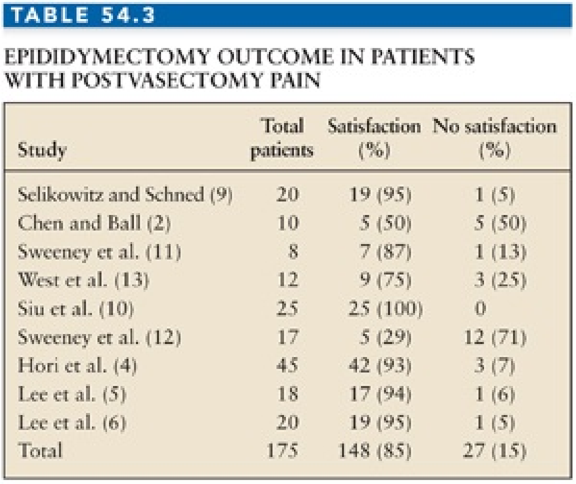

TABLE 54.3

EPIDIDYMECTOMY OUTCOME IN PATIENTS WITH POSTVASECTOMY PAIN

Study	Total patients	Satisfaction (%)	No satisfaction (%)
Selikowitz and Schned (9)	20	19 (95)	1 (5)
Chen and Ball (2)	10	5 (50)	5 (50)
Sweeney et al. (11)	8	7 (87)	1 (13)
West et al. (13)	12	9 (75)	3 (25)
Siu et al. (10)	25	25 (100)	0
Sweeney et al. (12)	17	5 (29)	12 (71)
Hori et al. (4)	45	42 (93)	3 (7)
Lee et al. (5)	18	17 (94)	1 (6)
Lee et al. (6)	20	19 (95)	1 (5)
Total	175	148 (85)	27 (15)

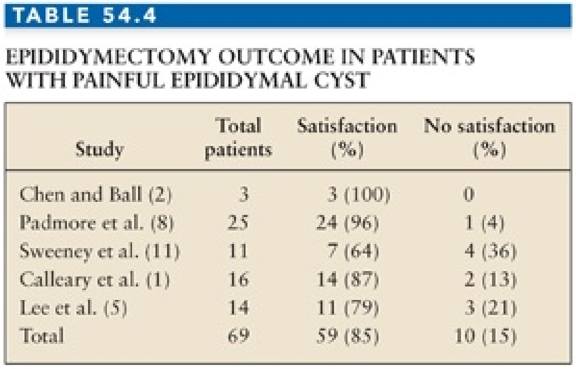

TABLE 54.4

EPIDIDYMECTOMY OUTCOME IN PATIENTS WITH PAINFUL EPIDIDYMAL CYST

Study	Total patients	Satisfaction (%)	No satisfaction (%)
Chen and Ball (2)	3	3 (100)	0
Padmore et al. (8)	25	24 (96)	1 (4)
Sweeney et al. (11)	11	7 (64)	4 (36)
Calleary et al. (1)	16	14 (87)	2 (13)
Lee et al. (5)	14	11 (79)	3 (21)
Total	69	59 (85)	10 (15)

CONCLUSIONS

Complete or partial epididymectomy remains a valuable resort for the management of chronic epididymal pain refractory to conservative and medical therapies. Various epididymal pathologies such as chronic infection/inflammation, complex epididymal cysts, and benign and malignant epididymal masses are additional indications for epididymectomy. It is our hope that the information provided in this chapter on preoperative counseling, intraoperative surgical techniques, and postoperative outcomes can help clinicians to be better prepared to deliver the best care to patients who require epididymectomy.

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CHAPTER 55 EJACULATION INDUCTION PROCEDURES

Anejaculation is defined as failure of ejaculation (retrograde or antegrade) and needs to be distinguished from **anorgasmia (lack of pleasurable sensation)** (1). Anejaculation can be a result of damage to the spinal ejaculatory center (spinal cord injury), peripheral and autonomic nervous system neuropathy (diabetes mellitus, retroperitoneal dissection), transverse myelitis, multiple sclerosis, or iatrogenic secondary to psychotropic medications (2,3). Psychogenic (idiopathic) anejaculation is a diagnosis of exclusion when no obvious pathology can be identified. Psychogenic anejaculation occurs in 30% of men who are unable to ejaculate. Considering time factor, anejaculation can be divided into two categories: primary (lifelong) failure to ejaculate voluntarily by either masturbation or through intravaginal intercourse and secondary anejaculation occurring in patients who report an ability to ejaculate in the past (4,5).

Since the time of the father of evidence-based medicine, Dr. Cochran, who himself suffered from anejaculation, little agreement exists about pathophysiology and optimal evaluation and treatment of men with anejaculation (6).

Most men undergo psychological evaluation first despite lack of prospective randomized trials that psychoanalysis is able to overcome primary anejaculation (6,7).

It is critical to determine if the patient has ever ejaculated voluntarily either by self-stimulation or intravaginally. Presence of **nocturnal emissions** excludes major neurologic deficits. Ability to achieve orgasm verifies that the patient is able to achieve adequate level of arousal and can reach the threshold level (arousal) necessary to activate the ejaculatory generator.

DELAYED EJACULATION

Definition

Delayed ejaculation (DE) is a condition in which it takes an extended period of normal sexual arousal and stimulation to achieve ejaculation and orgasm. In cases of DE, the intravaginal ejaculation latency time (IELT) is persistently lengthened, which may cause the individual to cease sexual activity prior to achieving orgasm due to exhaustion. This condition causes significant distress or interpersonal difficulties such that the patient seeks medical attention (8,9). DE can be either a lifelong condition, in which the patient has never experienced normal IELT (categorized as primary DE), or an acquired condition, in which the patient has previously experienced normal latency but now suffers from extended IELT (secondary DE). Some patients, particularly those suffering from secondary DE, are often able to masturbate themselves to orgasm despite difficulty achieving orgasm through sexual intercourse (8,10).

Rowland et al. (8) provided more specific criteria for the diagnosis of DE. As most sexually healthy males reach orgasm 4 to 10 minutes after vaginal penetration, men with a consistent IELT approximately two standard deviations above the mean (21 to 23 minutes) may be diagnosed with DE. In practice, Rowland et al. (8) suggest that men exhibiting latencies lasting longer than 25 to 30 minutes, in conjunction with the psychological distress described earlier, demonstrate sufficient symptoms for a diagnosis of DE.

Evaluation

In addition to detailed developmental and sexual history, full physical exam with neurologic exam should be performed. In patients who are not sure about the ability to achieve orgasm, we perform an ultrasonographic (US) orgasmic/ejaculatory study using **transperineal ultrasound**. The patient is allowed to self-stimulate using audiovisual adult materials after adequate erection is achieved via intracavernosal injection if needed. During ultrasound, the change in cross section of bulbous urethra (BU) (measure of arousal) is assessed and the patient is allowed to stimulate for up to 30 minutes. If the patient achieves progressive distention of BU and reaches central nervous system (CNS) threshold level for ejaculation, the rhythmic contractions of bulbocavernosal muscle (BCM) (regulated by spinal cord motor generator) are measured and indicate that subject achieved necessary arousal to initiate cascade of ejaculatory events. For those patients who suffer from retrograde ejaculation (RE), postorgasmic urine analysis will show sperm in men who have normal sperm production. Lack of sperm in urine does not exclude RE, as men with nonobstructive azoospermia (NOA) will not have sperm in ejaculate despite RE. If NOA is anticipated, then transrectal ejaculatory study with power Doppler allows one to clearly visualize flow of semen through the ejaculatory ducts and confirms RE or verifies a disorder of emission (Fig. 55.1).

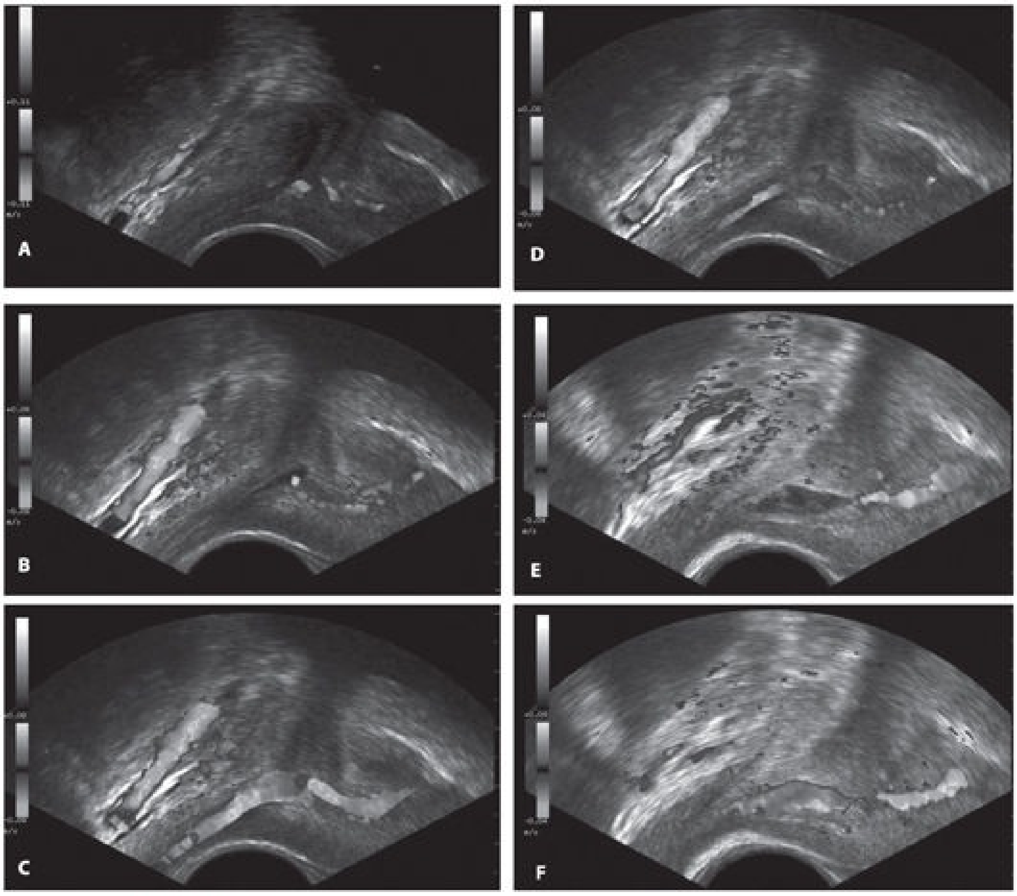

FIGURE 55.1 Flow of semen during ejaculation can be assessed using TRUS ejaculatory study. **A–F:** Progressive images taken at 10 ms intervals of one ejaculatory bolus indicates normal emission of semen from seminal vesicles through ejaculatory ducts into prostatic urethra and outside resulting in antegrade ejaculation.

Biothesiometry may help to identify men with decreased penile sensitivity (**age-related penile hyposensitivity**), which can be often treated with penile vibratory stimulation (11) (Fig. 55.2).

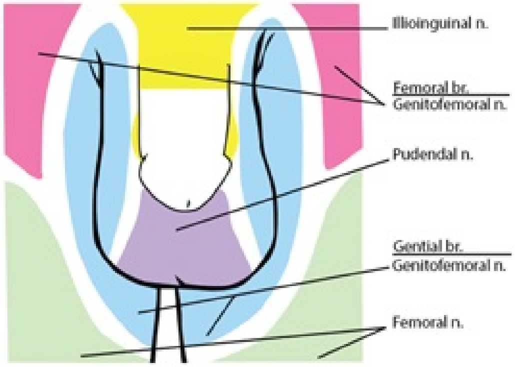

FIGURE 55.2 Innervation of the perineum and scrotum important in evaluation of ejaculatory dysfunction.

Medical Treatment

Corona et al. (12) and study of our own patients have shown that **hypogonadism is associated with anejaculation and DE**. Thus, correcting hypogonadism and improving erectile function is a first step in treatment of men with anejaculation or DE (arbitrary defined as >30 minutes of intravaginal stimulation). Erectile dysfunction is clearly associated with ejaculatory delay and anejaculation (13). Treatment with tadalafil has been shown to improve ejaculatory function (14). Review of our own experience indicates that testosterone level >650ng per dL may be needed to improve ejaculatory function but more research is needed in this area. Men with elevated prolactin (PRL) should have magnetic resonance imaging (MRI) of pituitary to exclude prolactinoma. Anecdotal reports indicate that empiric treatment with low-dose 0.25 to 0.5 mg of Dostinex has been associated with ability to ejaculate.

Medical therapy has been used for over three decades in men with anejaculation. Sympathomimetic agents have been a mainstay of medical therapy. They may work better in men who have RE, as they increase bladder neck resistance and direct flow of semen toward meatus. **Pseudoephedrine in doses of 30 to 120 mg** taken 1 to 2 hours prior to sexual intercourse can be used together with 5PDE inhibitor to improve erectile function. Imipramine has also been successfully used in RE (15). Midodrine has been successful in 50% of patients with anejaculation and RE but midodrine can result in very high blood pressure and is only approved for treatment of severe orthostatic hypotension (16,17).

Oxytocin analogs have been proposed as treatment of anejaculation, but clinical experience is at best limited. Recently, **trazodone** has been successfully used in men with disorders of orgasm and ejaculation secondary to selective serotonin reuptake inhibitors (SSRIs) (18). Trazodone may be considered in men who have nonorganic sexual dysfunction (19). SSRI weekend “vacation” buspirone, amantadine, and pramipexole (Mirapex) have all been proposed as potential treatment of anejaculation but no prospective trials exist to assess their efficacy (20).

Penile Vibratory Stimulation

Penile vibratory stimulation (PVS) has been used for therapeutic treatment of anorgasmia and to achieve ejaculation and help with erections (21,22) (Fig. 55.3).

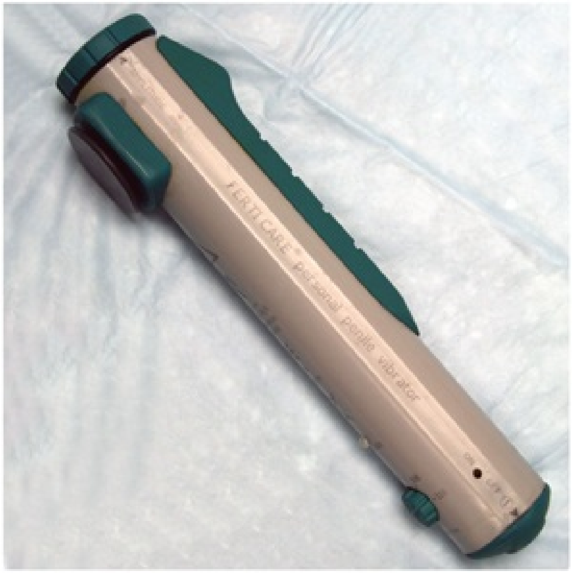

FIGURE 55.3 Penile vibrator has (a) amplitude adjustment, (b) frequency adjustment, (c) vibrating head, and (d) amplitude warning light.

Success of PVS depends on residual neuromotor control of ejaculatory centers. In complete upper motor neuron lesions, reflex erections can be achieved in 93% of men but antegrade ejaculation only in 5% of men (23). PVS has been successfully used as initial form of therapy in diabetic men with anejaculation and resulted in 50% of pregnancy rate. There seems to be a decrease in quality of semen parameters with nocturnal emission yielding highest concentration, followed by PVS and electroejaculation (EEJ) yielding lowest sperm concentration (24). PVS combined with at home vaginal self-insemination has resulted in 43% of pregnancies in men with spinal cord injury (SCI) (25).

Although testicular sperm extraction and epididymal aspiration of sperm in men with SCI and anejaculation combined with intracytoplasmic sperm injection is a feasible procedure, nonsurgical approaches should be initially tried (26).

PVS has been shown to result in higher density of sperm than EEJs (27,28). On average, men respond to **100-Hz vibration and 2.5-mm amplitude** in our practice using Ferticare vibrator (Fig. 55.4). In diabetic men, amplitude has to be increased up to 3.5 mm, but patient has to be instructed about possibility of skin erosion with vigorous use and limit pressure. We do not prescribe a Ferticare vibrator unless the patient demonstrates (in the office) that he can operate the vibrator safely. Skin erosion can occur in men with decreased genital sensitivity. Once the patient is able to ejaculate by self-stimulation with his partner present, he is encouraged to attempt intravaginal intercourse after achieving level of arousal close to ejaculation. This therapy was successful in 43/46 of men (93.4%) who were able to ejaculate by masturbation after mean follow-up of 14 months. Thirty out of 43 men who were able to ejaculate by self-stimulation were able to ejaculate intravaginally (own data). This combination therapy aimed at improving underlying pathology and focusing on increase of arousal has been recommended by ad hoc expert consultation on disorders of ejaculation and orgasm (8,29).

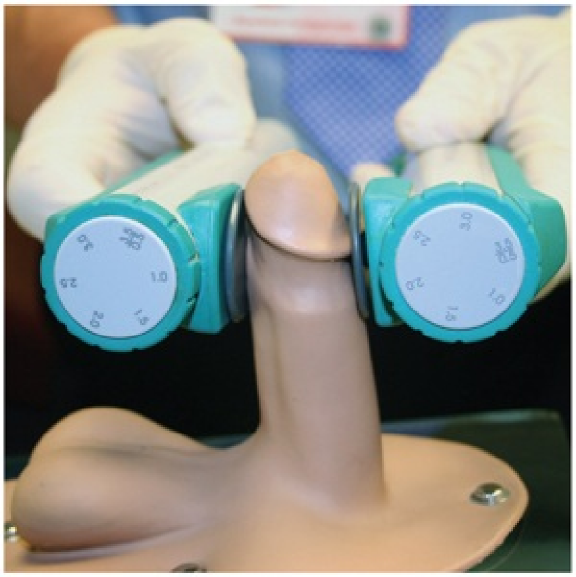

FIGURE 55.4 Two Ferticare penile vibrators can be used in men refractory to penile vibratory stimulation using maximum amplitude and frequency of single vibrator.

PVS has been successfully used in paraplegic men and in men with idiopathic anejaculation. In our practice, we always induce erection with either intracavernosal (IC) injection of 5 to 7 units of Trimix or 5PDE inhibitor given a couple of hours prior to vibratory stimulation (VST). VST is first performed under the supervision of a physician or trained registered nurse (RN), as skin erosion and abrasions are not uncommon in inexperienced patients or patients with decreased sensation in genital area. By progressive increase of amplitude and frequency of stimulation, ejaculation can be achieved within 10 to 20 minutes in most of patients with an intact nervous system and much quicker in patients with SCI (30). Once optimal settings are achieved in a sexual medicine laboratory, a prescription is given for the patient to use a vibrator at home. If the bulbocavernosus reflex (BCR) and the hip flexor response (HR) are both intact, the patient is much more likely to be successful with PVS as they, essentially, demonstrate a wholly active reflex arc and integrity of all of the neural pathways involved. Bird and colleagues reported that if both BCR and HR are positive, PVS is successful in inducing an ejaculatory reflex in 94% of men with an injury level between T1 and T6 and 67% of men with an injury level between T7 and T12. No patient was successful if neither reflex was positive. PVS allows for the retrieval of a semen specimen in a very simple fashion that can be used for home self-insemination, intrauterine insemination (IUI), or in vitro technologies. In the appropriate SCI male, PVS is the first-line option for treatment. The first-line option is *not* surgical sperm retrieval coupled with intracytoplasmic sperm injection.

Vigorous prostatic massage and in vitro fertilization (IVF) using sperm obtained during nocturnal emission has been reported, but the IVF success rate using those techniques is lower than expected (31).

Electroejaculation

EEJ should be considered when vibratory stimulation fails to induce ejaculation (30). Risk of autonomic dysreflexia in men with SCI below T5 is low (30). EEJ requires general anesthesia in patients with intact spinal cord and may lead to rectal mucosal injury (thermal injury). However, it is a rather rare complication if the rectal temperature is monitored (Fig. 55.5).

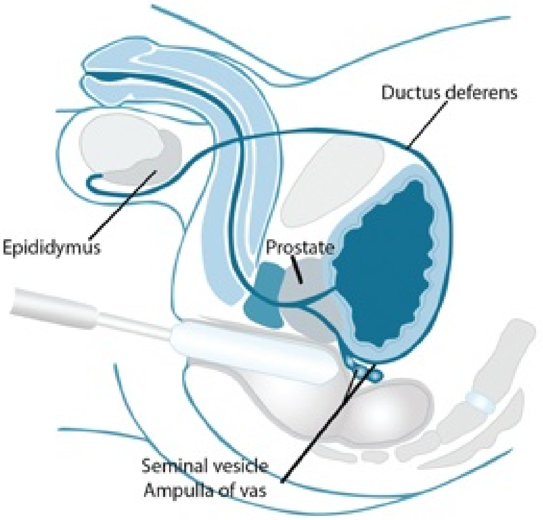

FIGURE 55.5 Position of the probe during electroejaculation. Longitudinal electrodes are pressed against the prostate seminal vesicles. Rapid increase in voltage and amperage leads to antegrade and retrograde ejaculation.

EEJ is a painful procedure in men with intact sensation in the lumbar or sacral region; thus, general anesthesia is required in men who have pinprick sensation in L–S dermatomes. Neuromuscular block (paralysis) is typically employed (32).

Indications include anejaculation due to SCI, retroperitoneal lymph node dissection (RPLND), idiopathic anejaculation, diabetes autonomic dysfunction, spina bifida, and multiple sclerosis.

Contraindications for EEJ include Crohn disease, ulcerative colitis, rectal cancer, large rectal fissure, extensive inflammatory changes in rectum, preexisting erosions of rectal mucosa, and patients with pacemakers.

Preparation: Alkalinization of urine is performed starting a day before by using 10 to 30 mL of Bicitra diluted in 4 to 8 oz of water with meals and the night before the procedure. A morning dose on the day of the procedure depends on the need for general anesthesia. Patients with SCI are advised to perform bowel evacuation the night before the procedure. Non-SCI patients perform an enema to clear the rectum. SCI patients prone to autonomic dysreflexia may be pretreated with subinguinal nifedipine 10 to 30 mg. The patient should report sudden headache or palpitations.

Position: left lateral position with adequate padding of the right forearm and placement of pillow in between the knees which should be slightly bent. The person collecting the specimen should stand in front of the penis and the person performing the EEJ stands behind.

The bladder should be emptied by catheterization using a plastic catheter in all EEJ cases and 5 to 20 mL of medium instilled in bladder. Anoscopy is performed to exclude any lesions of the anus and mucosa (Fig. 55.6).

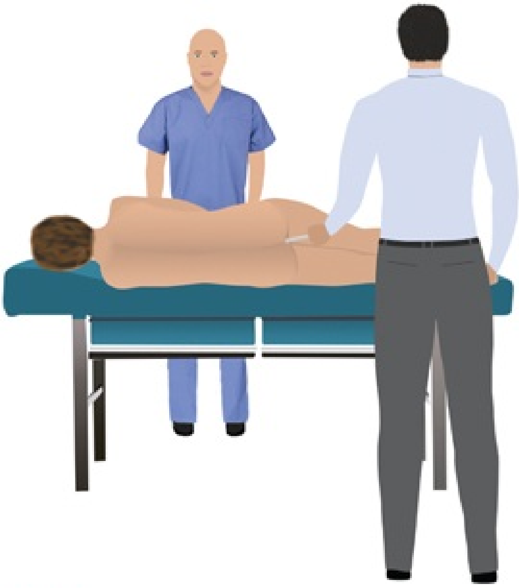

FIGURE 55.6 During EEJ, patient is placed in the lateral decubitus position with adequate padding of extremities. The EEJ operators insert the probe in the rectum and applies progressively increasing voltage to the prostate and seminal vesicles. The assistant stand in front of patient to collect semen through antegrade ejaculation in the sterile container. Retrograde ejaculate also has to be obtained by catheterization of the bladder. Assistant or anesthesiologist monitors patient's blood pressure to avoid life-threatening autonomic dysreflexia.

Equipment: Seager Electrostimulation Power Unit and Probes (Dalzell USA Medical Systems) is the most commonly used system approved for use in humans in the United States.

Probes: The probe has three attached linear electrodes embedded in medical grade PVC. Probes are placed in the rectum applying mild pressure to direct electrodes toward prostate and seminal vesicles. It is important that probe electrode surface temperature is monitored throughout the electrostimulation procedure. Temperature sensors are connected to a digital display on the power unit via the probe cord. The digital meter has both a warning light and an audible indicator showing when a set temperature has been reached. If the preset temperature should be reached, the warning audible will be activated and the machine will shut down. It cannot be used again until a different probe is selected. Standard-sized probes have diameters ranging from 1 inch (2.5 cm) to 1 516 inch (3.30 cm): 1 inch, 1 18 inch, 114 inch, and 1 516 inch (2.5 cm, 2.8 cm, 3.1 cm, and 3.3 cm). EEJ probes deliver an output of 0 to 40 V AC, the same frequency as the input power source (60 Hz), with current up to 1 Amp max.

Current is delivered by a rapid increase in voltage then held for 5 seconds and returned to 0 V. Starting voltage is typically 2.5 to 5 V and increased by 2.5 V intervals until antegrade ejaculation, peak voltage of 35 V, or temperature increase above 39.5°C. Gentle milking of the urethra may aid in collecting all the antegrade specimen into a collection cup. Subsequently, the bladder is catheterized and retrograde fluid collected. Anoscopy is performed again to document intact anal mucosa.

Monitoring: Blood pressure and heart rate are monitored and stimulation discontinued if systolic blood pressure exceeds 200 mm Hg or diastolic 130 mm Hg.

EEJ success depends on the underlying etiology, level and completeness of SCI, and time from SCI to EEJ (Table 55.1).

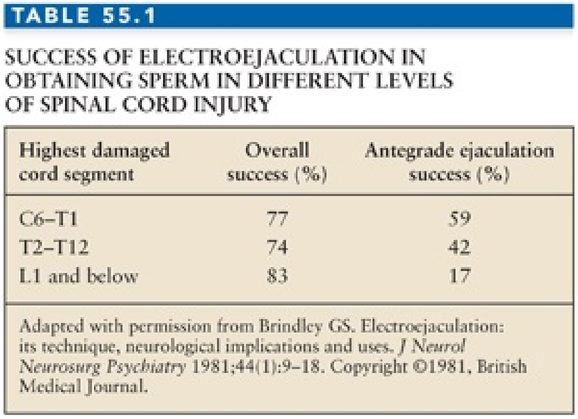

TABLE 55.1

SUCCESS OF ELECTROEJACULATION IN OBTAINING SPERM IN DIFFERENT LEVELS OF SPINAL CORD INJURY

Highest damaged cord segment	Overall success (%)	Antegrade ejaculation success (%)
C6–T1	77	59
T2–T12	74	42
L1 and below	83	17

Adapted with permission from Brindley GS. Electroejaculation: its technique, neurological implications and uses. *J Neurol Neurosurg Psychiatry* 1981;44(1):9–18. Copyright ©1981, British Medical Journal.

Failure of emission occurs with complete damage to the anterior horn of the L5–S2 regions. Depending on the nature of neurologic injury, patients can ejaculate antegrade, retrograde, or partially antegrade with RE. Thus, examination of the urine is always indicated. The antegrade specimen should be collected separately from retrograde specimen. Both antegrade and retrograde specimens should be delivered to the laboratory for further processing and either immediate use or cryopreservation.

Complications: Minor like abdominal discomfort or severe muscle spasm and UTI can occasionally happen. Autonomic dysreflexia and thermal injury to the rectum have to be discussed with patient. Colonization with methicillin-resistant *Staphylococcus aureus* (MRSA) and *Clostridium difficile* bowel infection has been reported.

Autonomic dysreflexia (AD) is a clinical medical emergency in individuals with SCI above the T6 level. An episode of AD is characterized by elevated arterial blood pressure (BP) and most commonly bradycardia but tachycardia can also be encountered. Elevation of systolic blood pressure (SBP) by 20 to 30 mm Hg in SCI patient during the procedure may be considered a dysreflexia episode. AD varies in intensity from asymptomatic minor BP elevation to severe headaches and life-threatening emergency with SBP climbing as high as 300 mm Hg. AD is typically triggered by irritation of the bladder or rectum (33). In patients with SCI who experience recurrent episodes of AD from self-catheterization or bowel emptying, preventive procedures like botulinum toxin injection into the detrusor or intravesical capsaicin may be considered first to decrease the risk of AD during EEJ. Use of lidocaine gel anally has decreased the incidence of AD in SCI (34). Management of the acute episode of AD consists of stopping the procedure which triggered AD and tilting patient upright (induces pooling of blood in the abdominal and lower extremity vessels). Use of antihypertensive drugs should be considered if SBP exceeds 150 mm Hg. Nifedipine 10 to 30 mg sublingually is an effective treatment of AD and if given 15 minutes prior to procedure can prevent a significant increase in BP in a patient prone to frequent AD. Captopril 25 mg has also been used successfully in acute episodes of AD (35). Prazosin 3 mg twice a day for 2 weeks prior to the procedure has decreased the number of episodes of AD.

Epididymal sperm aspiration or testicular biopsy is a next logical step to obtain sperm for IVF in failed EEJ. VST, EEJ, and epididymal aspiration or testicular biopsy remain important tools to obtain sperm for reproductive purposes in men with neurogenic anejaculation secondary to SCI and peripheral neuropathy (36). EEJ can also be considered in men with psychogenic anejaculation who fail medical treatment and behavioral modifications (37).

Retrograde Ejaculation

Evaluation of RE is straightforward as postorgasmic semen analysis revealing sperm confirms the diagnosis. Adequate amounts of sperm can be obtained from the retrograde ejaculate by catheterization. Urine alkalinization prior to retrieval of retrograde specimen is advised (38). If no sperm is identified, then color Doppler transrectal ultrasonographic ejaculatory study (TRUS-Ej) should reveal either failure of emission (lack of visible semen transfer from seminal vesicles) or azoospermia with RE if semen is seen flowing through the prostatic urethra and into the bladder (Figs. 55.7 and 55.8).

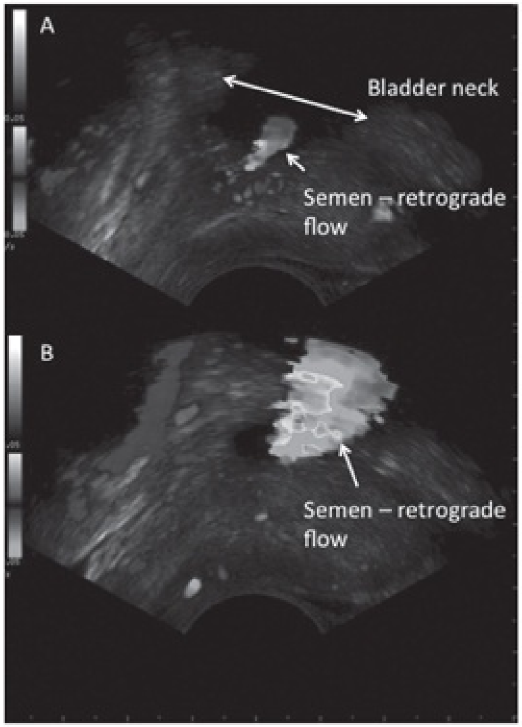

FIGURE 55.7 Retrograde ejaculation revealed by ejaculatory TRUS study in men with anejaculation and open bladder neck with no sperm identified in urine after ejaculation. Patient had bilateral obstruction of vas deferens from vasectomy. Notice open bladder neck and increase amount of semen flowing into the bladder.

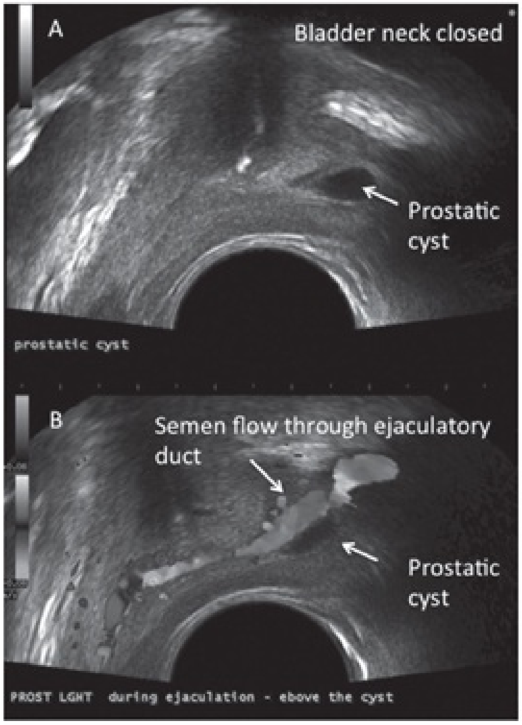
A
Bladder neck closed
Prostatic cyst
prostatic cyst
B
Semen flow through ejaculatory duct
Prostatic cyst
PROST LGHT during ejaculation - above the cyst

FIGURE 55.8 Transrectal ejaculatory study is helpful in evaluation of anejaculation and obstructions of the ejaculatory ducts. In example above, the patient with azoospermia and low seminal volume was found to have a prostatic cyst overlaying left ejaculatory duct. Ejaculatory study showed that the semen flows freely above the cyst; thus, cyst is nonobstructive.

Treatment

Urinary sperm retrieval remedies a patient's infertility caused by RE by collecting viable sperm from postejaculatory urine to achieve pregnancy through artificial insemination. Jefferys et al. (39) reviewed three retrieval methods. The first method is centrifugation and resuspension of postejaculatory urine specimens, in which a urine specimen is obtained through voiding or catheterization, then suspended in medium, centrifuged, and resuspended before being used for artificial insemination. This method has by far the largest sample size, achieving a 15% pregnancy rate (35 pregnancies achieved out of 229 cycles). The second method, the Hotchkiss technique, involves emptying the bladder through voiding or catheterization, then rinsing the bladder with Ringer lactate. Some of the Ringer lactate is then injected into the bladder, after which the patient was asked to ejaculate. The ejaculate is then collected through voiding or catheterization and used for artificial insemination. The Hotchkiss technique or modified Hotchkiss technique, although less frequently studied than centrifugation, has achieved a higher pregnancy rate of 24% (7 pregnancies out of 29 cycles). The final method of urinary sperm retrieval, ejaculation on a full bladder, was described by only two papers studied in the Jeffreys et al.'s (39) review. In each case, the patient ejaculated with a full bladder and the ejaculate was then suspended in Baker buffer. This method, although also suffering from a small sample size, has achieved a 60% pregnancy rate (3 pregnancies out of 5 cycles) (39).

A review by Jefferys et al. (39) identified three key treatment methods for RE, including the retrieval of sperm from postejaculatory urine, medical treatment, and surgical treatment. Here, we will summarize the efficacy of each method as identified in the Jefferys et al. (39) review.

Studies examining the medical management of RE used the achievement of antegrade ejaculation as the metric for successful treatment. Although the sample sizes for these studies are again too small to make definitive statistical conclusions, the findings suggest that a combined treatment of sympathomimetics and anticholinergics is most effective, achieving antegrade ejaculation in 39% of patients. Treatment with sympathomimetics (synephrine, ephedrine sulphate, phenylpropanolamine, or midodrine) or anticholinergics (brompheniramine maleate or imipramine hydrochloride) alone, in contrast, achieved antegrade ejaculation in 28% and 22% of patients, respectively (39).

Only two papers reviewed by Jefferys et al. (39) describe surgical procedures for the treatment of RE. The injection of collagen into the bladder neck, as described by Reynolds et al. in 1998, resulted in two pregnancies and one live birth. The surgical removal of sperm, as described by Rosalund et al. in 1998 also resulted in a pregnancy through intracytoplasmic sperm injection. However, investigators acknowledge that surgical treatment of RE risks testicular scarring and damage that may cause further exacerbate ejaculatory dysfunctions, and therefore, surgical options should be considered carefully before execution (39).

In our practice, we have used Deflux 3 to 4 mL per each treatment to progressively bulb up the bladder neck in men with RE caused by resection of the bladder neck. Each procedure is performed every 3 months. Fifty percent of men achieve some antegrade ejaculation.

SUMMARY

In the future, anejaculatory treatment will most likely include specific medications to enhance arousal and lower the threshold for spinal cord ejaculatory centers in men with an intact spinal cord. Activation of 5-HT1A and 5-HT2C receptors activates the spinal cord motor generator and decreases ejaculatory latency and increases the effectiveness of copulation in rats (40). Gulliano et al. has recently reported success with induction of ejaculation by microstimulation of lumbar spinothalamic neurons, thus giving hope for future microstimulation of ejaculatory centers in men with SCI (41).

In summary, recent advances in neurobiology and new imaging modalities have dramatically expanded our understanding of ejaculatory function in animals and humans and should lead to the development of specific medications to treat DE and anejaculation in patients without complete SCI.

ACKNOWLEDGMENTS

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CHAPTER 56 ANATOMY OF THE TESTIS

MARK SIGMAN

An understanding of normal testicular anatomy is important for all urologists involved in male reproductive surgery. Proper knowledge of normal allows recognition of those instances of abnormal anatomy. Inadvertent injury to testicular arteries may result in testicular atrophy and potentially infertility and hypogonadism. Many of the testicular structures are extremely small, which has led to the adoption of magnification provided by an operating microscope by male reproductive surgeons. There is often a close coloration between physical exam findings and findings on surgical exploration. Small soft testes usually indicated impaired or absent spermatogenesis. Small firm testes are often associated with sclerosis and scarring of the testicular parenchyma, which may make testicular microdissection more difficult. Therefore, the surgeon should be familiar not just with normal anatomy but the particular physical exam findings on the patient to be operated on which will help preparation for the actual surgical procedure.

GROSS ANATOMY

Testicular Position

The testes are ovoid organs that lie within the scrotum with the long access of the oval, usually, but not always, in a vertical direction. The epididymis is most commonly aligned in a vertical posterior direction attached to the posterior surface of the testes. Normal testicular size is commonly reported to be 15 to 25 mL in volume (1) when measured with bead-like orchidometers; however, the recorded size depends on the measuring device used and often larger sizes obtained with devices such as punched out elliptical rings with which normal adult sizes commonly exceed 30 mL (2). The right testis is often slightly larger than the left. The testis and epididymis reside within the parietal layer of the tunica vaginalis (Fig. 56.1). Often attached to the caput epididymis is the appendix epididymis, whereas just in front of this is another embryologic remnant, the appendix testis. Either of these structures may torse resulting in pain. The capsule of the testis is actually composed of three layers. The most superficial layer is the visceral layer of the tunica vaginalis followed by the thickest component, the tunica albuginea, which consists of bundles of collagen fibers. From a surgical point of view, these two layers act as one, and surgical incisions into the capsule are closed in one layer. Underneath the tunica albuginea is the tunica vasculosa, which is a thin delicate layer that contains a plexus of small blood vessels. These vessels are easily injured during incisions into the testicular capsule. Delicate septations arise from the tunica albuginea separating groups of seminiferous tubules into lobules. The tunica albuginea is thickest along the posterior portion of the testes where it forms the mediastinum testis which extends into the posterior portion of the testis. Within the mediastinum is the rete testis that connects the seminiferous tubules to the efferent ductules (Fig. 56.2).

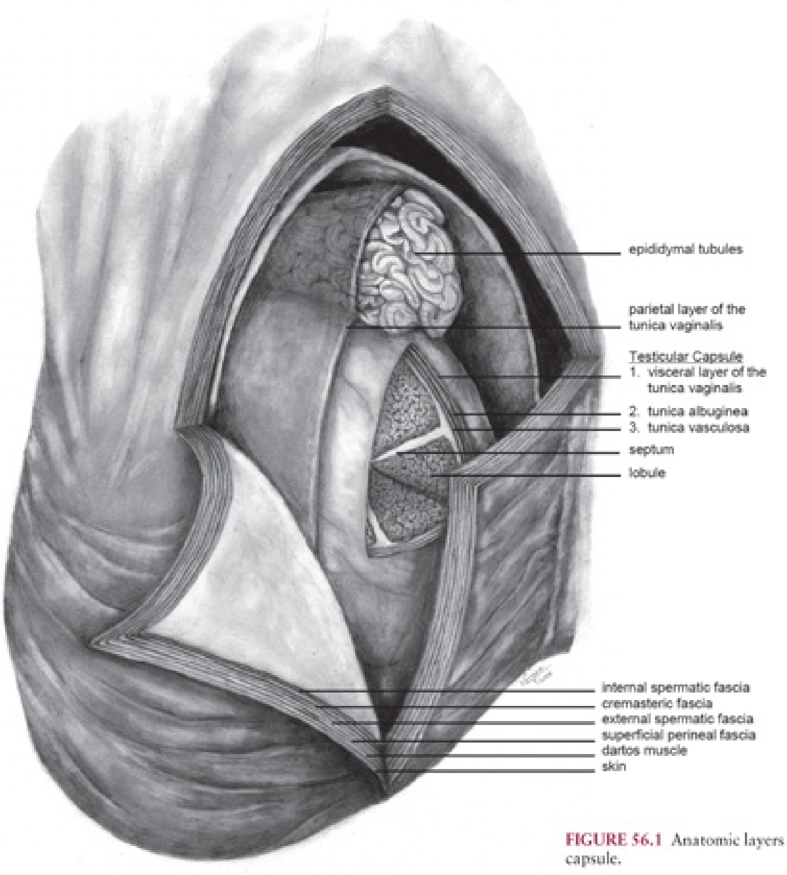
epididymal tubules
parietal layer of the tunica vaginalis
Testicular Capsule
1. visceral layer of the tunica vaginalis
2. tunica albuginea
3. tunica vasculosa
septum
lobule
internal spermatic fascia
cremasteric fascia
external spermatic fascia
superficial perineal fascia
dartos muscle
skin

FIGURE 56.1 Anatomic layers of the scrotal wall and testicular capsule.

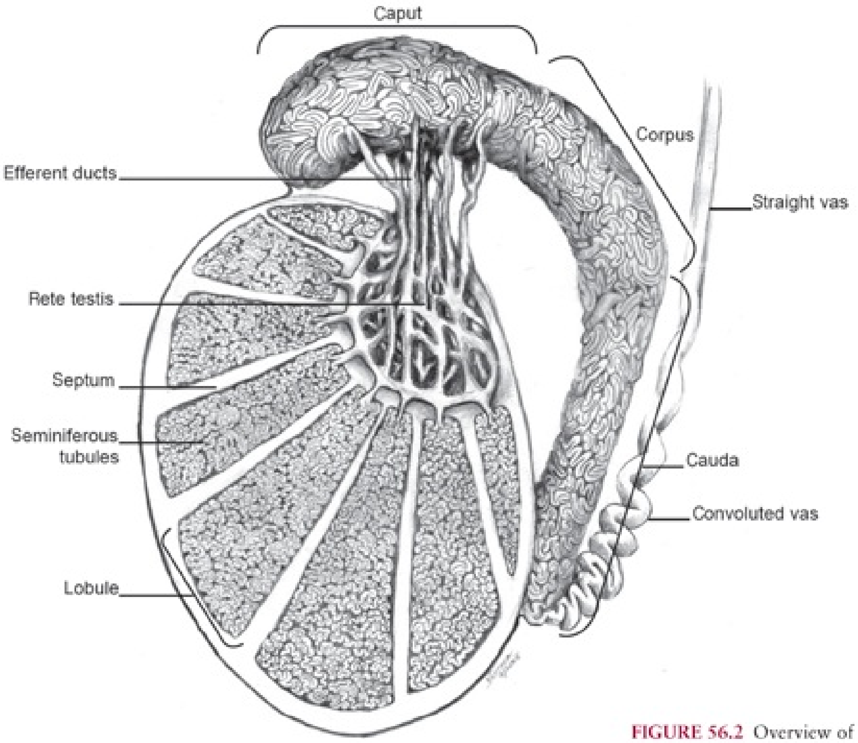

FIGURE 56.2 Overview of testicular anatomy.

BLOOD SUPPLY

The testis has three arterial supplies. Two-thirds of testicular blood supply derives from the testicular artery with the remaining one-third divided between the deferential and cremasteric arteries (3). The testicular artery, also referred to as the internal spermatic artery (Fig. 56.3), arises directly from the aorta at level L3 below the renal arteries. It crosses anterior to the ureter and lies on the anterior surface of the psoas major muscle. The right testicular artery also crosses anteriorly to the vena cava; however, it is posterior to the bowel including the duodenum, root of the mesentery, terminal ileum, as well as the arteries associated with those portions of the bowel (right colic artery and the ileocolic artery). The left testicular artery is similarly posterior to the distal portion to the descending colon as well as the left colic artery and the inferior mesenteric vein. Both the right and left testicular arteries begin as single arterial structures. Once they enter the spermatic cord, the arteries may branch and thus one to three or more testicular arteries may be found within the spermatic cord (4,5). The numbers of testicular arteries and veins within the spermatic cord increase as the cord travels from the pelvis through the internal ring toward the scrotum. Although there is considerable variation in the pelvis, there is usually one artery and two veins. The mean number of vessels at the level of the inguinal canal is 2 arteries and 8 veins, whereas at the level of a subinguinal incision it is 3 arteries and 11 veins. A single testicular artery is present in 69% of cords within the inguinal canal, whereas this is the case only 25% of the time in the subinguinal region (6). In addition, the arteries in the subinguinal region are much more likely to be surrounded by a complex of veins than in the inguinal region. Thus, varicocele repair in the subinguinal region is technically more demanding than if performed in the inguinal canal (7).

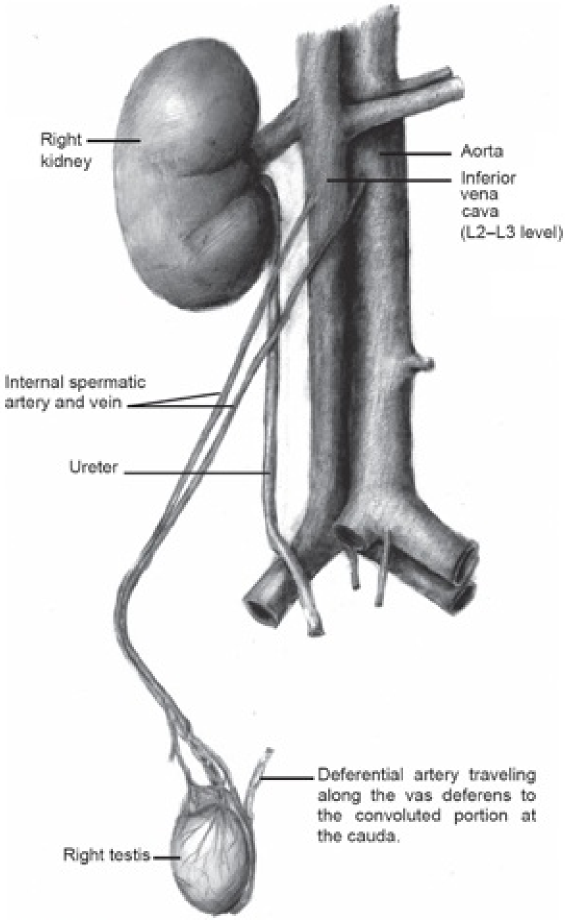
Right kidney
Aorta
Inferior vena cava (L2–L3 level)
Internal spermatic artery and vein
Ureter
Deferential artery traveling along the vas deferens to the convoluted portion at the cauda.
Right testis

FIGURE 56.3 Testicular blood supply (cremasteric vessels not pictured).

As with the arterial blood supply within the spermatic cord, there is considerable variation in the course of the arteries within the testis. The arteries enter the testis beneath the epididymis, usually in the corpus region. These capsular arteries travel in the tunica vasculosa in an inferior direction toward the lower pole, sending out other capsular branches interiorly. The arteries also then ascend from the lower pole superiorly along the anterior surface of the tunica vasculosa. Branches extend from the anterior surface over the testicular parenchyma (Fig. 56.4). Centripetal arteries descend within the septa between lobules. Before reaching the rete testis, they leave the septa as recurrent arteries, enter the lobule and travel vertically back towards the tunica—the opposite direction of the centripetal arteries. Segmental arterioles branch off the recurrent arteries in the interstitium which branch further as as interstitial arterioles. These arterioles form branching capillaries among Leydig cell clusters. Some of these leave the Leydig cells as inter-Leydig cell capillaries and penetrate into the lamina propria of the seminiferous tubules, and after some distance, these intramural capillaries leave the seminiferous tubule wall and are again surrounded by Leydig cells. They then continue as postcapillary interstitial venules which enter intralobular small veins (Fig. 56.5) (8).

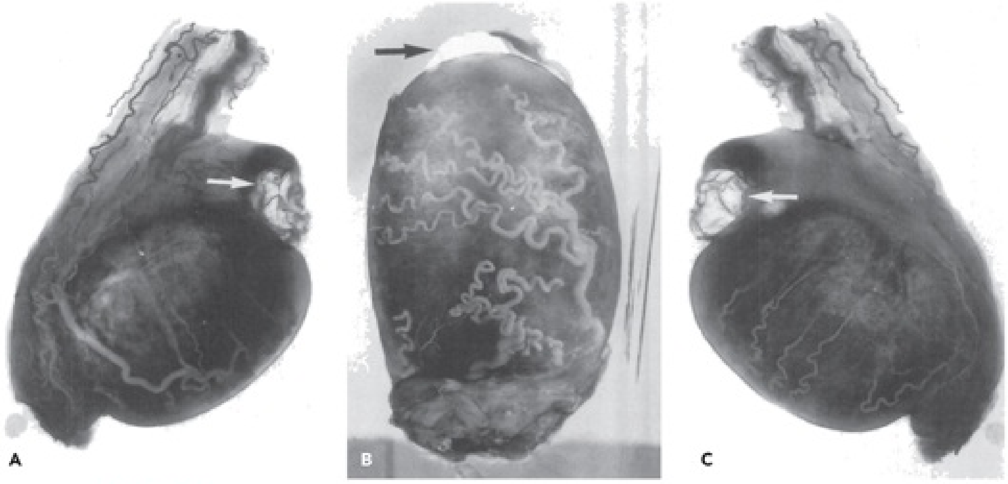

FIGURE 56.4 Subcapsular testicular blood supply. Medial (A), anterior (B), and lateral (C) surfaces of the testis. The *arrows* indicate the appendix epididymis. (Reprinted from Jarow JP. Intratesticular arterial anatomy. *J Androl* 1990;11(3):255–259. Copyright American Society of Andrology. Reprinted with permission of Wiley.)

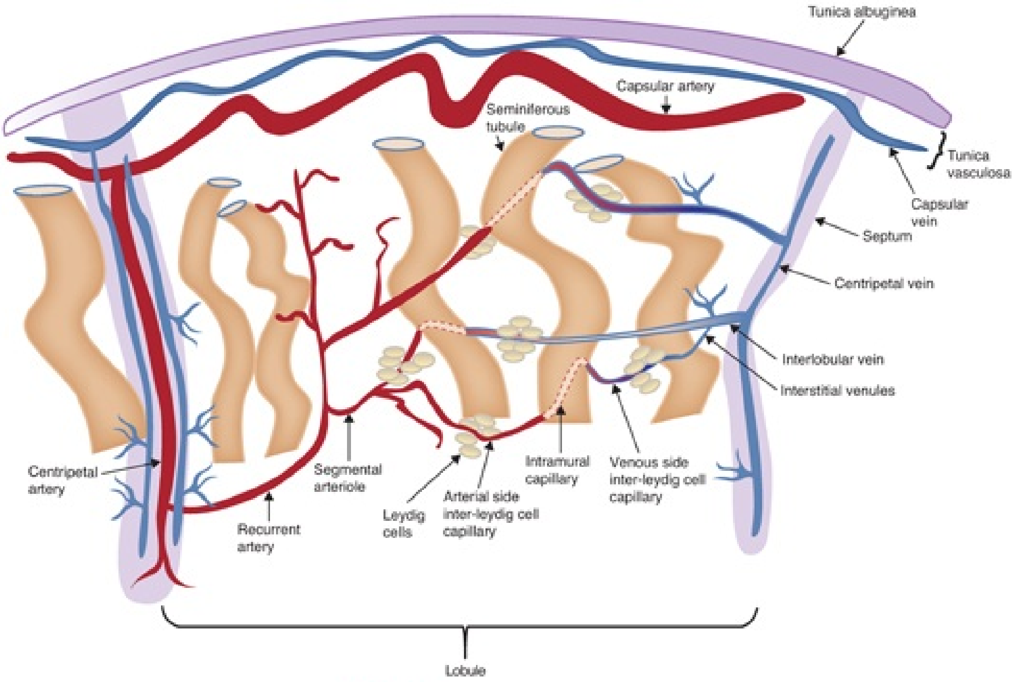

FIGURE 56.5 Microvasculature of the testis.

Often, but not always, the least vascular regions of the testis are the medial and lateral surfaces of the superior pole (6). However, incisions in the upper pole, if under the caput epididymis, may injure the rete testis and interfere with the entry of sperm into the efferent ductules and therefore should be avoided. Often, the midsection of the testis has fewer vessels, and a horizontal incision in this region is commonly used for testicular sperm retrieval. However, because of the variability of arterial blood flow, optical magnification should be used and allows for the identification of less vascular regions of the anterior surface of each individual testis. The deferential artery travels with the vas deferens after branching from the superior or inferior vesicular artery. It travels inferiorly toward the cauda of the epididymis. In general, this remains a single artery throughout the course of the vas deferens. The cremasteric artery branches off from the inferior epigastric artery. It travels on the cremasteric fascia to the surface of the tunica vaginalis.

There are extensive communicating channels between the various arterial supplies to the testis. The communicating channels between deferential and testicular arteries have been reported in 87% of humans, whereas communications between the cremasteric artery and the testicular artery have been found in 50% of specimens (9). The testicular artery anastomoses may occur at any point from the internal inguinal ring to the tunica albuginea. In contrast, the deferential artery tends not to demonstrate anastomoses until the level of cauda epididymis. In general, the testicular arteries tend to be larger than either the cremasteric or deferential arteries. Considerable variation in size may exist between branches of the testicular artery, with some branches being quite small and therefore easily injured during surgery. Optical magnification is very helpful in identifying these small branches.

There are four potential venous outflow systems from the tests: testicular (spermatic), vasal (deferential), external cremasteric, and gubernacular veins. Intratesticular veins travel between the lobules of the seminiferous tubules interconnecting in the tunica vasculosa, but they do not follow the course of the intratesticular arteries. They exit posteriorly either near the mediastinum following the course of the rete testis or exit through the tunica to superficial veins on the testicular capsule (10). These veins merge with deferential veins forming the pampiniform plexus in the spermatic cord. Within the spermatic cord, there are more testicular veins than arteries. The testicular arteries are typically closely adherent to veins that have multiple interconnecting anastomoses (11). This is thought to be important for countercurrent heat exchange. As a result, intratesticular temperatures are 3° to 4° lower than rectal temperature (12). The deferential veins follow the vas deferens proximally. External cremasteric veins lie within the cremasteric muscle fibers and may exit the cord through the floor of the inguinal canal or in the subinguinal region, draining into the inferior epigastric vein (13). Finally, gubernacular veins exiting the tunica vaginalis through the gubernaculum have been identified in 79% of varicocelectomy patients (4). The significance of the gubernacular veins is unclear—some have suggested they are a potential source of varicocele recurrence if they are not ligated (4); however, others have demonstrated no benefit in clinical outcomes to ligation of these veins (14).

Proper knowledge of the testes arterial, venous, and lymphatic anatomy is important for male reproductive surgery. Because there is considerable variation in the number of testicular arteries, it is not surprising that some studies have demonstrated testicular atrophy from testicular artery ligation, whereas others studies have not (15,16,17,18,19,20,21). In addition, high ligation of the artery is less likely to result in atrophy than low ligation because of the interconnections between the vasal and testicular arteries. This characteristic is used with the Fowler-Stephens orchiopexy (22). During microsurgical varicocele repair, the testicular arteries are spared but occasionally may be injured. However, because of the anastomotic channels or the presence of multiple arteries, testicular atrophy only occurred in 5% of the cases of testicular artery ligation (23). Of note, during vasectomy, the deferential artery may be injured; therefore, performance of a simultaneous varicocele repair and vasectomy has an increased chance of testicular atrophy. The use of optical magnification allows the surgeon to identify and preserve testicular deferential and cremasteric arteries to lessen the chance of atrophy. Similarly, with varicocele repair, all the testicular veins within the cord are ligated, leaving only the deferential (and possibly gubernacular) veins to provide venous drainage. Ligation of deferential, testicular, and cremasteric veins, as may be intentionally done for testicular denervation for orchialgia, risks testicular atrophy. During testicular biopsy or testicular sperm retrieval, incisions into the testicular capsule should follow a direction less likely to cross blood vessels—typically in a medial to lateral direction. Within the testicular parenchyma, performing dissection between lobules lessens injury to the intratesticular vasculature (24). These subcapsular vessels can be seen and avoided using an operating microscope (25).

LYMPHATIC DRAINAGE

Lymphatic channels leave the testis and tunica vaginalis, forming trunks within the spermatic cord. Commonly, four to eight lymphatic channels may be identified. With traditional nonmagnified varicocele repair, these channels were inadvertently ligated resulting in a high incidence of postoperative hydroceles (approximately 15% to 25%). Lymphatic sparing microsurgical varicocele repair has reduced the postoperative hydrocele incidence to 1% or less (26).

INNERVATION

Testicular pain is mediated by both sympathetic nerve fibers, which travel next to the testicular arteries as well as branches from the ilioinguinal and genital femoral nerves. Autonomic nerves derived from the 10th to 11th thoracic spinal segments form ganglions in the regions of the vena cava and aorta near the takeoff of the gonadal arteries (27). The nerve fibers then descend along the path of the testicular arteries, forming a superior and inferior spermatic nerve (28). Parasympathetic fibers originating from the vagus nerve and the inferior spermatic nerve innervate the lower pole of the testis as well as the vas deferens and epididymis (28). Beyond carrying pain fibers, the exact role of these nerves in testicular function remains unknown. For the reproductive surgeon, the important points of testicular innervation are that within the spermatic cord the nerves are microscopic and multiple. In a recent study, approximately 25 microscopic nerves were identified within the spermatic cords (29). Because these nerves are small, it is, therefore, easy to temporarily denervate the testis with a spermatic cord block with local anesthetic infiltration into the cord. Although this only temporary elevates pain, this accurately identifies patients that have significant pain relief of orchialgia from spermatic cord denervation procedures (30). Because the nerves tend to be microscopic, they are not individually ligated rather the testicular arteries, lymphatics, and some venous drainage is preserved, whereas the remaining cord structures are ligated and divided. This approach assures division of the multiple microscopic testicular nerves. Depending on the patient’s fertility concerns, the vas deference may or may not be spared (31).

TESTICULAR PARENCHYMA

The testicular parenchyma consists of seminiferous tubules and interstitial tissue. Within the seminiferous tubules are Sertoli cells, germ cells, and tubular fluid. The interstitium contains Leydig cells, blood vessels, lymphatics, fibroblasts, macrophages, and mast cells. Seventy percent to 80% of the testis is composed of seminiferous tubules with the remainder consisting of interstitial tissue (10). There are approximately 600 to 1,200 seminiferous tubules within the human testis (32). The seminiferous tubules are coiled looped structures with the ends of the tubules in the rete testis and the tubules extending radially from that point toward the periphery. The rete testis leads to 6 to 12 efferent ducts which pass through the tunica albuginea and enter and form the caput epididymis. From a surgical prospective, with microsurgical technique, it is possible to separate the lobules of seminiferous tubules and to dissect between individual seminiferous tubules in a radial fashion without extensive injury to the testis. With optical magnification, the surgeon often finds Leydig cell nodules in testes of infertile men. Lymphatic structures are typically not visualized within the interstitium during testicular surgery but are visualized within the spermatic cord. All spermatogenesis takes place within the seminiferous tubules; therefore, the tubule diameter and color depends on the status of spermatogenesis. Tubules containing normal spermatogenesis tend to have a pale yellow-orange color and are opaque when examined under the operating microscope (Fig. 56.6A). In contrast, tubules with Sertoli-only patterns have a smaller diameter, appear white and semitranslucent (see Fig. 56.6B).

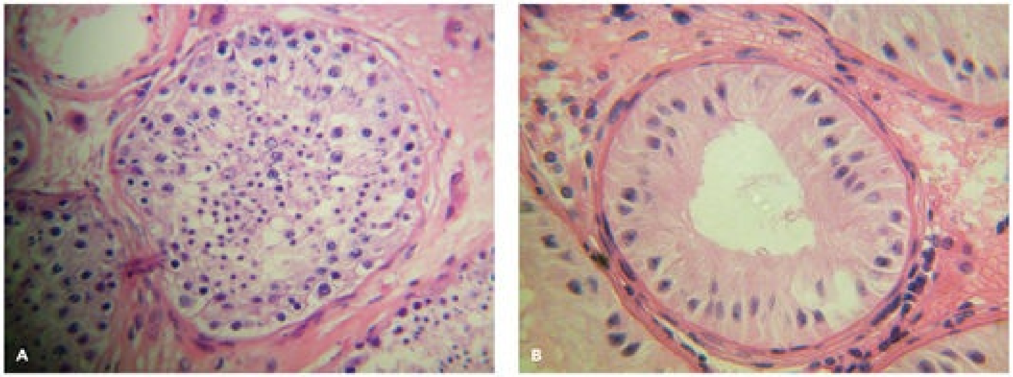

FIGURE 56.6 A: Normal testicular histology, 400×. B: Sertoli-only histology, 400×.

SUMMARY

The last decade has seen significant advances in testicular surgery. It has become clear that optical magnification and a proper knowledge of the testicular anatomy is imperative for the success of surgery and the avoidance of testicular artery injury, causing impaired testicular function, and lymphatic ligation, causing hydrocele formation.

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CHAPTER 57 SPERM RETRIEVAL TECHNIQUES

KELLY A. CHILES AND PETER N. SCHLEGEL

Azoospermia is defined as the complete absence of sperm in the ejaculate after analysis of two ejaculated specimens. Up to 15% of infertile men are azoospermic, and the etiology can be either obstructive azoospermia (OA) or nonobstructive azoospermia (NOA). OA is estimated to be responsible for 40% of cases of azoospermia and can result from such varied causes as congenital absence of the vas deferens or ejaculatory duct obstruction and iatrogenic etiologies such as vasectomy, injury to the vasa during inguinal surgery, or injury to the epididymis from scrotal surgeries such as hydrocelectomy. NOA comprises the remaining cases and results from failure of the testis to produce sperm. It is imperative that the clinician determine through careful history and exam if the cause is lack of sperm production or obstruction because this will dictate the optimal approach for sperm retrieval. For NOA, only the testis can be targeted for retrieval purposes; however, with OA, the vas deferens, epididymis, and/or testis can likely be used.

OA can be suspected based on history (prior vasectomy or bilateral inguinal surgeries), physical exam (normal testicular volume [>20 mL], absent vasa, or congested epididymides), and laboratory values (normal follicle-stimulating hormone [FSH] [<8 mIU/mL], positive serum antisperm antibody assay, or decreased ejaculate volume [<1.5 mL]) (1). NOA can similarly be suspected based on history (known hypogonadism), physical exam (atrophic testis), and laboratory values (FSH elevated 2 to 3 times upper limit of normal, negative antisperm antibody assay, karyotype anomalies, or Y chromosome microdeletions). In addition, men with ejaculatory dysfunction such as anejaculation or retrograde ejaculation are also candidates for epididymal sperm retrieval, although some of these men may also use less invasive sperm retrieval techniques such as penile vibratory stimulation, electroejaculation, or postejaculatory urine sperm retrieval depending on the etiology of their aspermia. Furthermore, men with obstruction may benefit from reconstruction, particularly if more than one biologic child is desired, because primary reconstruction is more cost-effective than sperm retrieval and repeated in vitro fertilization (IVF) cycles. If the female partner, however, has fertility issues that necessitate IVF and intracytoplasmic sperm injection (ICSI), surgical sperm retrieval may be more appropriate than reconstruction.

There are expected differences in the quality and quantity of spermatozoa retrieved based on the etiology of azoospermia, method of recovery, and tissue of origin. Epididymal sperm is often more mature and motile, whereas testicular sperm is usually immotile except in the case of obstruction. Notably, the virtually limitless supply that is recovered with microsurgical epididymal sperm aspiration (MESA) allows multiple samples that can be frozen for future IVF cycles and has a distinct advantage over the more limited numbers harvested from testicular tissue. The sperm retrieval can be done any time prior to the IVF cycle with multiple vials cryopreserved. Percutaneous epididymal sperm aspiration (PESA) generally has a relatively low yield of sperm, most of which are severely damaged with low motility. Percutaneously retrieved sperm with very poor motility may reduce IVF success rates, and low sperm motility may adversely affect the ability to freeze sperm for future use. Patients should be counseled accordingly regarding this possibility.

Sperm retrieval from men with impaired sperm production (NOA) for use with assisted reproductive technology (ART) is preferentially performed the day before oocyte retrieval, although it can be performed the same day if necessary. Timing is important because all methods of sperm retrieval commit the female partner to ART, and the female can be spared an unnecessary procedure if no sperm are found and the couple defers the use of donor sperm. It is recommended that surplus sperm be frozen for potential use in the future so as to spare the male partner additional procedures. Although it is understood that there is an expected loss of up to half of the frozen spermatozoa during the freeze-thaw process, there is no data to suggest that the sperm which survive the freeze-thaw process are inferior to fresh sperm. In fact, there seems to be no difference in either the fertilization or pregnancy rate from fresh or frozen-thawed sperm when men have normal sperm production and are obstructed (2). For men with normal production and obstruction, elective sperm retrieval for freezing prior to the IVF/ICSI cycle may be preferred. For men with NOA, best results are obtained fresh sperm.

Contraindications to sperm retrieval efforts include anyone who cannot undergo scrotal surgery such as men with active groin or urinary infections or men who are not physically able to withstand the stress of surgery. Retrieval is not recommended for men with complete deletions of the AZFa or AZFb regions of the Y chromosome because no patients have had sperm found with these conditions. Relative contraindications include men who have already undergone a failed, thorough bilateral microscopic-assisted testicular sperm extraction (microTESE) by a trained microsurgeon because the chance of successful sperm retrieval in these men is virtually zero.

INTRAOPERATIVE SPECIMEN EVALUATION

All methods of sperm retrieval warrant evaluation under phase-contrast microscopy during the procedure in order to document if sperm have been retrieved and degree of motility. Additional pathologic evaluation of a permanent specimen or analysis by an andrology laboratory does not replace the real-time information which can be obtained from a properly performed intraoperative wet prep. In the case of testis biopsy, a touch prep is prepared by gently touching a slide to the cut surface of the testis, adding a drop of human tubal fluid (HTF) media. For epididymal aspirations, a tiny drop of aspirated specimen is placed on a slide, mixed with HTF, and for TESE specimens, after complete tissue dispersion of the retrieved sample by the urologist, a small fraction of tissue is placed on a slide. After a drop of HTF is added, a cover slip is carefully placed. Analysis under a microscope at 400× magnification will not only reveal the presence or absence of sperm but motility can be assessed as well. The presence of many motile or immotile sperm in the testis or in the epididymal fluid confirms the diagnosis of OA in men who are candidates for reconstruction (3). The identification of adequate (enough to fertilize all retrieved oocytes), viable (at least twitching) sperm during a TESE procedure signifies success, and the procedure can be terminated.

A permanent, fixed touch prep is a second kind of specimen evaluation that is most useful in men with NOA. After touching a slide to the cut surface of the testis, it is fixed with 95% ethyl alcohol and stained with the Papanicolaou technique. This technique is specifically used to differentiate between late maturation arrest and complete spermatogenesis. It allows the pathologist to scan through multiple depths of the specimen to identify if the spermatozoa have developed tails or not. Traditional permanent section of biopsy specimens uses such thin-cut paraffin embedded specimens that pathologists are unable to identify if the spermatozoa have tails, and thus, they cannot differentiate between late maturation arrest and complete spermatogenesis without the aid of touch preps.

TESTIS BIOPSY

Indications

Testicular biopsy for fertility purposes has both diagnostic (documenting the degree of spermatogenesis in order to predict the chance of successful sperm retrieval) and therapeutic (providing sperm for use in conjunction with ART) benefits, and the decision to biopsy is tightly linked to the serum FSH levels and physical exam of the patient. Biopsy is indicated in azoospermic men with normal FSH levels and testicular size/consistency, at least one palpable vas deferens, and a negative antisperm antibody assay to differentiate OA from NOA. Biopsy can be performed prior to a more invasive procedure such as vasal or epididymal reconstruction in order to verify spermatogenesis, or it can be performed concomitantly with TESE in order to provide diagnostic information regarding degree of spermatogenesis or associated histology. Testis biopsy is not indicated prior to sperm retrieval efforts for azoospermic men who clinically have primary testicular failure. Furthermore, men with congenital bilateral absence of the vas deferens and normal FSH and testicular size always have sperm production, and biopsy is therefore not indicated prior to undergoing sperm retrieval.

It is imperative that biopsy results be interpreted with caution in cases where no spermatogenesis is seen. The testicular parenchyma is not homogenous, and a biopsy will only sample a very small fraction of the 600 to 800 seminiferous tubules. The four histologic subtypes which can be found include normal spermatogenesis, hypospermatogenesis, maturation arrest, and Sertoli cell–only; on occasion, a biopsy will demonstrate more than one histologic subtype. Because there can be small foci of spermatogenesis randomly scattered throughout the testis, a random biopsy that does not demonstrate any spermatogenesis does not preclude sperm production elsewhere. When determining the chance of successful sperm retrieval, the most advanced stage of spermatogenesis is always used instead of the most prevalent stage. Men who have no germ cells (Sertoli cell–only histology) appreciated on testis biopsy are still candidates for TESE because these men have approximately a 35% to 40% chance of finding sperm during formal microTESE. The chance of successful sperm retrieval for maturation arrest and hypospermatogenesis are, respectively, about 71% and 96% when microTESE is undertaken (4).

Intratubular Germ Cell Neoplasia

One admittedly controversial indication for testicular biopsy is in men at increased risk of testicular cancer or intratubular germ cell neoplasia (ITGCN). These include men who have a history of male factor infertility, cryptorchidism, contralateral testicular cancer, and atrophic testis (<12 mL) and patients with disorders of sex development (5). Men who are undergoing orchiectomy for testicular cancer can consider concomitant contralateral testicular biopsy because up to 9% of these men will have ITGCN in the contralateral testicle (6). Prepubescent boys undergoing orchidopexy do not warrant biopsy because of the rarity with which ITGCN is found, although adult males undergoing orchidopexy for undescended testis should consider it because 1.7% of men with a history of cryptorchidism are found to have ITGCN. The pathologic finding of ITGCN lends itself to additional controversy because there is no gold standard for management. Although 70% of men with ITGCN will develop a germ cell tumor within 7 years, immediate treatment is not always required. Radical orchiectomy is typically done for men with ITGCN and a contralateral normal testicle. Radiation therapy is considered for men with a solitary testicle to preserve androgen production.

Technique: Testicular Sperm Aspiration, Percutaneous Testicular Biopsy, and Open Biopsy

Testicular biopsy can be performed in either the office or the operating room. When testis biopsy is performed with a fine needle, it is known as testicular sperm aspiration (TESA); when performed with a biopsy gun, it is often called a percutaneous testicular biopsy (PercBiopsy); and when performed open, it is simply referred to as a biopsy. Proper positioning of the testis within the scrotum is paramount regardless of approach. With the epididymis secured posteriorly, the testicle is held by the surgeon’s nondominant hand with the skin stretched tightly over the anterior surface. For percutaneous approaches, we routinely use 1% lidocaine diluted 9:1 with 8.4% sodium bicarbonate for local anesthesia; injection is into the skin initially and then deeper into the tunica. When performing TESA, an 18- to 25-gauge syringe is introduced along the long axis of the testis (Fig. 57.1). Tubule architecture is intentionally disrupted with repeated passes of the needle in multiple directions while continuously aspirating. For more ample tissue retrieval, PercBiopsy is used. A small 2- to 3-mm nick in the skin is made to facilitate passage of a 14-gauge × 10-cm core biopsy gun (Fig. 57.2). Introduction of a needle or biopsy gun should preferentially be in the anteromedial or anterolateral superior pole of the testis because this is the area least likely to contain larger arterial branches running deep to the tunica albuginea.

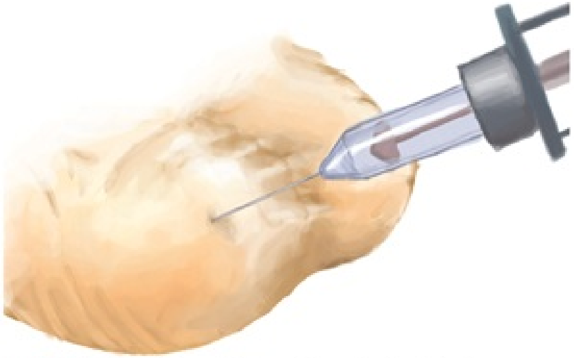

FIGURE 57.1 Technique of fine needle aspiration of testis.

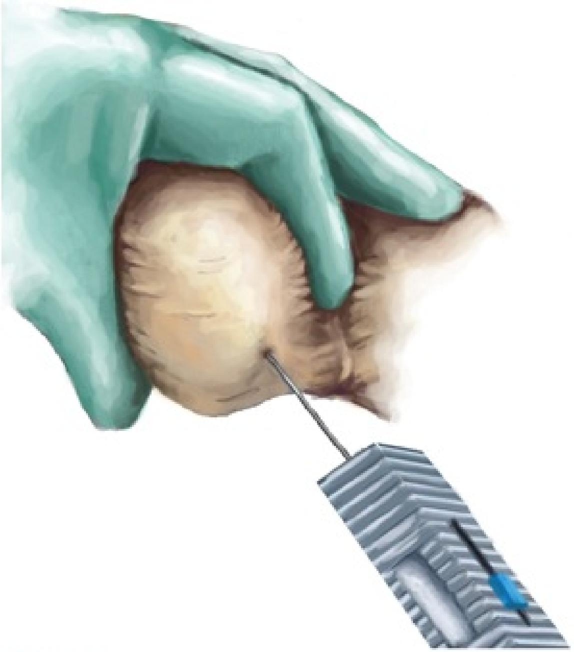

FIGURE 57.2 Technique of PercBiopsy.

For an open biopsy, a 1-cm incision is carried down to the level of the tunica albuginea. Optical loupes or preferably an operating microscope provides sufficient visualization of the subtunical blood supply (7). A stay suture (preferably polypropylene or nylon) is placed through a nonvascular region of the tunica albuginea. Using a 15-degree microknife, a 0.5-cm transverse incision is made in an avascular spot. Seminiferous tubules should easily extrude without applying significant pressure; if not, the tunica incision should be deepened or lengthened to facilitate easy delivery of tubules (Fig. 57.3). Excess pressure and manipulation of the tissue should be minimized in order to preserve the architecture as much as possible. The specimen can be sharply excised and placed in either Bouin, Zenker, or collidine–buffered glutaraldehyde solution; formalin should be avoided because it distorts seminiferous tubular architecture. Hemostasis is achieved with a microbipolar cautery. The tunica albuginea is closed with 5-0 polypropylene or Vicryl, tunica vaginalis with 4-0 Biosyn, and the dartos layer closed hemostatically with 4-0 Biosyn; skin closure is effected with subcuticular 5-0 Caprosyn. A 0.25% bupivacaine with epinephrine is injected in the subcutaneous tissue.

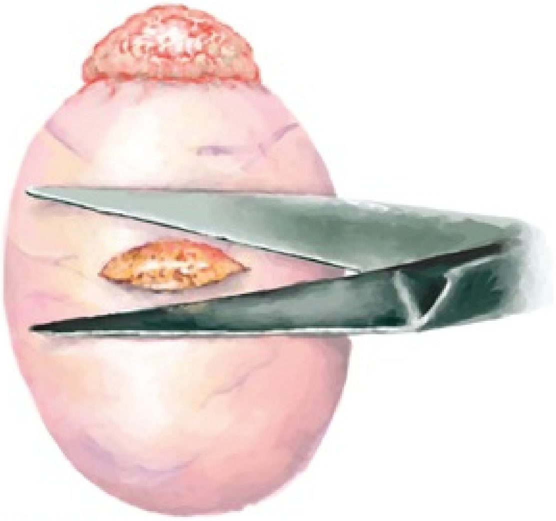

FIGURE 57.3 Technique for open testicular biopsy.

Importantly, there are a few distinctions in biopsy technique regarding whether it is being performed for oncologic purposes or fertility preservation. In cases of high suspicion for malignancy or ITGCN, an inguinal approach should be used. Furthermore, specimen preservation should take into account the likely need to perform immunohistochemistry, and as such, formalin can be used so as to allow appropriate tissue manipulation. If Bouin fixative is used, the pathologist should be alerted because this may change his or her choice of tests. In addition, fine needle aspiration and percutaneous biopsy do not sample enough tissue to provide a diagnosis, and thus, open biopsy is more likely to yield the needed volume.

Technique: Conventional Testicular Sperm Extraction and Microscopic-Assisted Testicular Sperm Extraction

Conventional and microTESE differ only in the use of an operating microscope to allow approximately 15× magnification; although the operative steps are analogous, the greater magnification allows the direct evaluation of individual seminiferous tubules which significantly increases the duration of the microTESE procedure compared to conventional TESE but improves the chance that the tiny biopsy samples taken will contain sperm. Under general or spinal anesthesia, a median raphe incision just large enough to deliver the testis is made. At this point in microTESE, an operating microscope is used to provide the 6× to 8× optical magnification which allows subtunical blood vessels to be easily visualized. The tunica albuginea is incised with a 15-degree ultrasharp knife in an avascular plane along the midpole of testis (Fig. 57.4). Bipolar cautery is used to maintain hemostasis and minimize injury to tubules adjacent to blood vessels. The testis is gently bivalved along its equatorial plane to widely expose the parenchyma. Strict attention is paid to minimizing tissue injury with gentle handling, and the authors recommend liberal use of “Saturday night hands” (8). Examination of the tubules occurs under 10× to 15× magnification, and every plane of the testis is systematically investigated in order to identify relative differences in tubule diameter and color. Larger, opaque or whiter tubules are more likely to contain germ cells and have some degree of spermatogenesis. A homogenous appearance of tubules can portend a poor retrieval prognosis. If no promising tubules are appreciated, additional dissection in the upper and lower poles are performed to thoroughly visualize all aspects of the testis. Unlike testicular biopsy where only a fraction of the superficial seminiferous tubules are sampled, all aspects of the testicular parenchyma are extensively surveyed. Centrifugal vessels that course along the septae separating tubules are avoided.

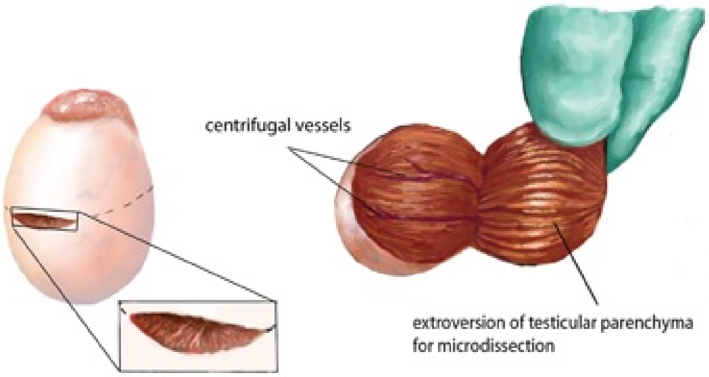

FIGURE 57.4 Technique of microTESE. *Inset* shows dilated epididymal tubules of varied appearances. The most dilated, yellow tubules should be avoided as they predominantly contain macrophages and degenerating sperm.

Only tubules judged to have the most likely chance of containing sperm are retrieved and set aside for processing prior to delivery to the andrology laboratory. Tubule processing is one of the most critical steps in successful retrieval efforts, and this is routinely managed by the urologist at our institution in order to guarantee meticulous preparation prior to microscopic examination. The microTESE technique allows for relatively small amounts of testicular tissue to be excised (up to 5 mg). In addition to preserving testicular function through minimal tissue removal and minimizing bleeding/cautery, this small volume lends itself to complete tissue disruption, optimizing sperm release from inside the tubules with mechanical disruption. The excised tubules are first placed in a small amount of buffered human tubule fluid or similar media supplemented with 6% Plasmanate. Iris scissors are used to initially separate the tightly coiled tubules until no individual clumps of tubules can be appreciated. This homogenate is next repeatedly aspirated and passed through a 24-gauge angiocatheter to assure complete dispersion of the testicular tissue. Embryologists routinely examine a small fraction of every surgical specimen in the operating room during the microTESE procedure. If no sperm are found initially, we continue our search until all planes of the testis have been surveyed, with each surgical specimen being processed and examined in real time, dictating the degree of our search. If no sperm are found after an exhaustive search of one testis, we will deliver the contralateral testis through the same scrotal incision and begin the search anew. Retrieval efforts are complete when either sperm are identified in the operating room or all areas of both testes have been completely examined. Prior to closure of the tunica, meticulous hemostasis is obtained because any subsequent scar which develops in the testis after sperm retrieval efforts is secondary to postoperative bleeding. Closure of the tunical layers, dartos, and skin is effected as described earlier. In addition, injection of 0.25% bupivacaine under the tunica vaginalis, along the spermatic cord, and into the scrotal sac is used. A total of 40 mL of bupivacaine is typically used to provide effective block of the multiple sources of innervation to the testis/scrotum. The subcutaneous tissue is injected with 0.25% bupivacaine and epinephrine.

Outcomes: Testicular Sperm Retrieval

As with any surgical procedure, infection and bleeding are known risks that can be minimized with meticulous hemostasis and attention to detail. Unique to testicular sperm retrieval efforts, testicular function decline is also a risk. We have found that limiting postoperative bleeding through meticulous hemostasis will minimize scarring and thus reduce subsequent androgen decline. Because men with NOA often have a baseline deficit of testicular function, it is not surprising that there is a measurable decrease in testosterone production that may not fully return to baseline after sperm retrieval efforts (9). The ultimate serum testosterone level is determined, in part, by both baseline hormone production as well as the extent of surgery. Notably, open techniques such as MESA and TESE involve longer operating times, and microTESE, although providing the greatest chance of sperm retrieval in the context of the least testicular damage, often necessitates the longest duration under general anesthesia.

The gold standard of sperm retrieval for NOA is microTESE when taking into account the higher success rates as well as ability to limit damage to the testicle (10). We have routinely demonstrated success in over 50% of men with NOA, including men with multiple prior failed attempts using conventional open methods, and scarred and atrophic testis. Our results have shown that microTESE results are independent of serum FSH levels and testicular volume. Even men with very atrophic testes and markedly elevated FSH have similar chances of sperm retrieval to men with borderline FSH levels because the microTESE procedure is able to identify even limited areas of sperm production in these grossly abnormal testes. The most recent data at Weill Cornell revealed a sperm retrieval success rate of 794 of 1,414 (56%) that translated into a fertilization rate of 4,423 of 8,705 injected oocytes (51%), and ultimately, a live delivery rate of 41% (11) of couples in whom viable sperm were successfully retrieved on microTESE.

EPIDIDYMAL SPERM RETRIEVAL

Technique: Percutaneous Epididymal Sperm Aspiration

After subcutaneous and spermatic cord block, the epididymis is firmly positioned against the scrotal skin and a 21- to 25-gauge needle and tuberculin syringe are used to aspirate fluid. The small volume of aspirate is often on the order of microliters and can be expanded with about 0.1 mL of human tubule fluid in the syringe. Additional samples can be taken traveling along the epididymis from cauda to caput until adequate healthy, motile sperm are found via intraoperative evaluation of small aliquots of specimen. Blind punctures of the caput should be limited to avoid the inherent risk of injury to the major vessels which insert into the testis immediately adjacent and inferior to the caput.

Technique: Microsurgical Epididymal Sperm Aspiration (Preferred Technique)

Under local or general anesthesia, a single median raphe incision or two transverse scrotal incisions within the scrotal skin folds is made, the hemiscrotum entered, and the tunica vaginalis opened widely. Using an operating microscope, the epididymis is exposed and carefully surveyed. Grossly dilated yellow/brown tubules are predominantly identified throughout the length of the epididymis and color noted. These yellow tubules are likely to contain nonviable, damaged sperm with blunt tails and many macrophages. The tubules containing clear golden fluid are more promising in providing sperm with optimal motility than tubules containing thick yellow fluid. Iris scissors are used to remove a 2- to 3-mm buttonhole of overlying epididymal tunic before the dilated tubule is punctured with a micropipet to aspirate this very sperm-rich fluid (Fig. 57.5). Alternatively, and not requiring specially prepared sharp, pointed pipettes, an opening is made in the tubule with a 15-degree microknife. Fluid is then aspirated into readily available standard 5-μL laboratory pipettes (12). Only minute amounts of fluid may be aspirated; however, this fluid is incredibly concentrated; typically a million sperm are found in each microliter of epididymal fluid. Because these men often have long durations of obstruction, it is not uncommon to find healthier appearing, motile sperm closer to the caput than the cauda. As with TESE, samples are evaluated intraoperatively to confirm the aspiration of adequate, viable sperm. The site of puncture is sealed with bipolar cautery prior to returning the testis to the scrotum, and the scrotum is closed as previously described with the liberal use of local anesthetic.

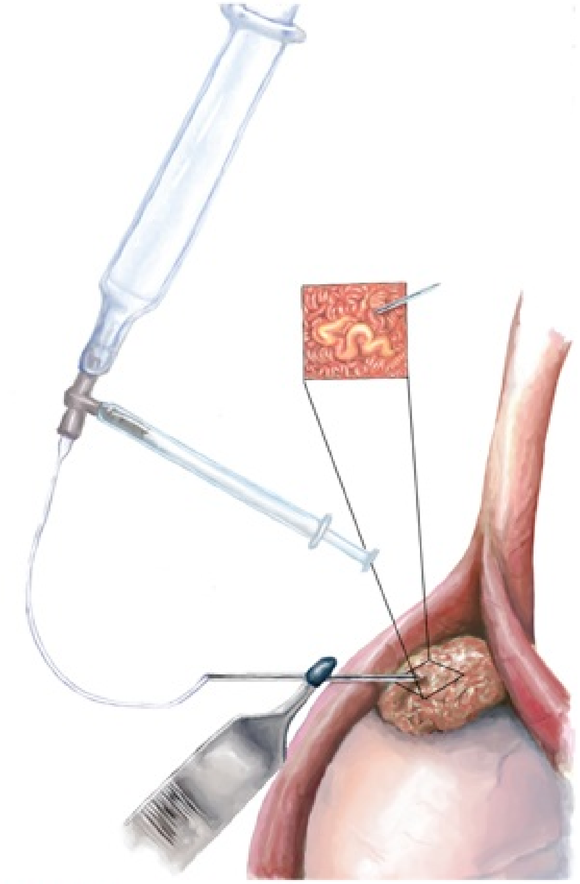

FIGURE 57.5 Technique of MESA. *Inset* shows dilated epididymal tubules of varied appearances. The most dilated, yellow tubules should be avoided as they predominantly contain macrophages and degenerating sperm.

Outcomes: Epididymal Sperm Retrieval

The risk of injury to blood vessels secondary to blind puncture of the epididymis with PESA precludes its use at our institution. Hematoma and pain are the immediate complications of such bleeding; however, it is the subsequent testicular atrophy secondary to injury to the testicular vessels that poses the greatest long-term risk to the patient.

MESA in the context of OA is over 99% successful regardless of etiology of obstruction. PESA has a relatively decreased chance, in the range of 80% to 90% successful. MESA, notably, also yields millions of sperm which can be easily cryopreserved into multiple vials, obviating the need for any future sperm retrieval procedures (13,14). Notably, partners of men with congenital bilateral absence of the vas, a defect associated with cystic fibrosis, should also be tested for mutations of the cystic fibrosis transmembrane conductance regulator gene given the frequency of cystic fibrosis mutations in the general population.

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CHAPTER 58 SIMPLE ORCHIECTOMY

JONATHAN L. SILBERSTEIN

Simple orchiectomy involves the removal of one or both testes at the distal spermatic cord, usually through a transscrotal approach. Importantly, this is in direct contrast to a radical orchiectomy performed through an inguinal incision performed for a testicular mass with suspicion of malignancy. Radical orchiectomy is intended to remove the entire testis, epididymis, and distal spermatic cord up to the inguinal ring without violating the scrotum and disrupting the normal testicular lymphatic drainage. In contrast, a simple orchiectomy is used for the treatment of benign intrascrotal processes, such as epididymoorchitis unresponsive to antibiotics, or a devitalized testicle secondary to torsion or trauma. If the etiology of a testicular lesion is unclear and there is any possibility of malignancy, we favor an inguinal approach as it will not violate the scrotum and the added morbidity is minimal.

The testis account for 95% of circulating testosterone, and bilateral simple orchiectomy may be used as a method of surgical castration to rapidly deplete circulating androgens (1). Surgical castration may be used for palliation in men with metastatic prostate cancer and will result in normalization of prostate-specific antigen and objective tumor response in the vast majority of patients albeit at the cost of profound metabolic changes resulting in increased rates of cardiovascular disease, metabolic syndrome, fatigue, osteopenia/osteoporosis, depression, and loss of libido (2). Rarely, surgical castration via bilateral simple orchiectomy may be performed to reduce sexual recidivism among sexual predators (3). Importantly, regardless the intended rationale for surgical castration, medical castration may achieve the same desired effects without the burden of surgery and is the preferred option in many nations.

DIAGNOSIS

Diagnoses requiring simple orchiectomy depend on the condition being treated and vary greatly between benign intrascrotal processes and metastatic prostate cancer. For benign intrascrotal processes requiring simple orchiectomy, such as epididymoorchitis unresponsive to antibiotics, or devitalized tissues secondary to torsion or trauma, diagnosis is most commonly made through careful history and physical exam. Patients should be asked about the chronicity of the onset of their symptoms (acute, chronic), location (laterality, isolated to the scrotum), history of trauma or surgical intervention, lower urinary tract symptoms (urgency, frequency), or systemic symptoms (fever, rigors). The clinician should perform a thorough physical examination of the abdomen, inguinal region, spermatic cord, scrotal skin, testes, tunica vaginalis, epididymis, and rectal exam when indicated. Additionally, the cremasteric reflex should be assessed by stroking or gently pinching the skin of the upper thigh while observing the ipsilateral testis, absence of this reflex suggests testicular torsion, which may be a surgical emergency. If the etiology of a scrotal process is equivocal after history and physical examination, color Doppler ultrasonography is the diagnostic test of choice because it is inexpensive, noninvasive, and will provide information on vascularity as well as anatomic details (4). Radionuclide scintigraphy is an alternative imaging option and will provide information on testicular vascularity but without anatomic details of ultrasound. Importantly, acute processes potentially requiring simple orchiectomy may be emergent, and if radiology is not available, suspicion is high, or the viability of the testis is in question, immediate exploration of the scrotum with intraoperative inspection and Doppler should be performed in lieu of delayed intervention following radiographic evaluation. For patients with chronic testicular pain, laboratory evaluation with urinalysis, urine culture, urine microscopy, semen culture, and urethral swab for sexually transmitted disease evaluation may be helpful in determining the diagnosis of a bacterial orchitis.

The diagnosis of metastatic prostate cancer requiring castration may be made via digital rectal exam and prostate-specific antigen screening prompting transrectal ultrasound-guided biopsy and ultimately radiographic imaging demonstrating systemic disease. Alternatively, patients with previously treated local disease may be diagnosed with biochemical recurrence or progression prompting radiographic evaluation.

INDICATIONS FOR SURGERY

Indications for simple orchiectomy depend largely on the diagnosis; in cases of penetrating scrotal trauma or blunt scrotal trauma with suspicion rupture of the testis, immediate scrotal exploration and intraoperative assessment is required (5). Even with rupture of the testis, salvage is often still possible with debridement of necrotic and extruded seminiferous tubules followed by closure of the tunica albuginea, although complete rupture may require orchiectomy (6). For suspected orchitis or epididymitis resulting from probable urinary tract infection, treatment with antibiotics and supportive care will almost always obviate the need for scrotal exploration and orchiectomy. Even for patients with Fournier gangrene, necrotizing fasciitis around the male genitalia, requiring emergent surgical debridement, the need for orchiectomy is rare due to the independent blood supply to the testis. Simple orchiectomy may be performed for chronic orchalgia after exhaustive efforts have been made to resolve issue with nonsurgical intervention, although the preferred intervention is microsurgical denervation with transection of the branches of the genitofemoral nerve and preservation of the testis, vas, and testicular artery (7). In cases of testicular torsion at the time of scrotal exploration, the testis is detorsed and observed; if viable orchiopexy is performed and if not viable, then simple orchiectomy to remove ischemic tissue is necessary.

Malignant diseases of the testes, such as suspected germ cell tumor, should never be managed with simple orchiectomy through a transscrotal approach. Suboptimal approaches to testicular neoplasms, including scrotal orchiectomy and transscrotal biopsy, can alter the normal lymphatic drainage of the testis and increase the burden of therapy for the patient (8). A meta-analysis of 206 cases of scrotal violation reported a local recurrence rate of 2.9%, compared to 0.4% for patients treated with inguinal orchiectomy, but no difference in systemic relapse or survival were appreciated (8). Therefore, if there is any suspicion of testicular cancer, a radical orchiectomy through an inguinal incision should be performed.

The indications for surgical or chemical castration in the treatment of advanced prostate cancer are not altogether clear. Although it is clear that castration is beneficial for patients with symptomatic metastatic disease (9) and should be avoided in those with localized disease because it may result in decreased overall survival (10), for patients who do not fit into either of these categories, the timing of initiation of castration is controversial. Medical castration is an alternative to bilateral simple orchiectomy. Although surgical castration rapidly results in a decrease in circulating androgen (1), medical therapies can achieve a similar result either through inhibition of androgen synthesis, blockade of the androgen receptor, or inhibition of gonadotropin-releasing hormone (GnRH). The most commonly used modality of medical castration are GnRH agonist; analogues of GnRH that inhibit the pituitary gonadal axis, resulting in the downregulation of luteinizing hormone–releasing hormone receptors and subsequent decrease in gonadotropin secretion. Importantly, these cause a temporary increase, or flare, in the available androgen and may result in exacerbation of life-threatening symptoms and coadministration to block the flare with an antiandrogen is standard practice. For patients with impending spinal cord compression, surgical castration or medical castration with ketoconazole provides the most rapid declines in circulating androgen to prevent impending impingement. Although the psychological effects of surgical castration can be daunting for the patient, from an economic viewpoint, surgical castration is much more cost-effective than medical castration. One last consideration is that surgical castration is irreversible, whereas medical castration may be given intermittently, although to date, there is an ongoing debate whether intermittent androgen blockade has equivalent outcomes.

SURGICAL TECHNIQUE FOR SIMPLE ORCHIECTOMY

Orchiectomy when performed electively is a straightforward outpatient procedure that may be performed with local, regional, or general anesthesia. Local anesthetic sensory blockade is obtained by infiltrating the spermatic cord in the region of the vas deferens in the high scrotum just below the pubic tubercle with a 0.5% bupivacaine solution. Care must be taken to ensure that the block is not injected intravascularly by drawing back on the syringe prior to injecting the medication. The same solution is then injected subcutaneously at the site of the scrotal incisions. Sensory blockade should then be tested with pickups before the beginning of the procedure. For scrotal exploration in cases of blunt or penetrating trauma, general anesthesia may be preferable because the extent of the exploration may not be fully realized at the start of the procedure. If simple orchiectomy is performed for castration and no prosthesis is to be placed, antibiotic prophylaxis is not absolutely indicated; however, it is our preference that a first-generation cephalosporin should be given intravenously within 30 minutes of scrotal incision. Antibiotic prophylaxis is mandatory for trauma, possible infectious etiologies, or when placing a testicular prosthesis.

Scrotal Approach

Scrotal approach to the simple orchiectomy may be through a single midline incision or two separate lateral incisions over the upper portion of the scrotal cord. Two incisions may decrease the need for mobilization and potentially reduce the risk for postoperative hematoma but may increase morbidity. Regardless of how many incisions are made, the first step is to shave the anterior scrotal wall to remove existing hair; the scrotum and genitalia are then prepared in a sterile manner. A 2.5- to 3.0-cm midline incision is made just through the skin within the median raphe in the anterior scrotal wall using a no. 15 blade scalpel while the assistant pushes a testicle toward the incision between his or her thumb and index finger so that the testicle lies directly under the incision (Fig. 58.1). By electrocautery, the incision is then carried down through the dartos and cremasteric layers until the parietal portion of the tunica vaginalis is incised directly over the testis. This is usually evidence by a gush of fluid from the peritesticular space. The incision in the tunica vaginalis is lengthened in both directions, enough to allow exposure of the entire testicle through the wound. The surrounding tunics are freed from the spermatic cord by a combination of blunt and sharp dissection. Meticulous hemostasis may be obtained in each layer as it is entered with electrocautery. Once the spermatic cord is isolated, the vas deferens is separated, doubly clamped, divided, and ligated with 2-0 Vicryl or 2-0 silk ties (Fig. 58.2). The remainder of the cord structures may be divided into one or more bundles and are doubly clamped on the proximal side and singly clamped on the distal side. Once divided, the proximal portion of the cord is ligated with a 0 Vicryl or silk free tie behind the most proximal clamp, which is then removed, and a 0 Vicryl suture ligature is placed just distal to the free tie (see Fig. 58.2). Before the cord is released to retract proximally, the tunics, dartos, and subcutaneous areas are again inspected for hemostasis. Once this is felt to be adequate, the cord is allowed to retract and attention is turned to the opposite testicle. It is then removed through the same midline or a separate transverse scrotal skin fold incision in the same manner. This leaves two openings in the tunica vaginalis and dartos layers, which are separated by a median septum. These deep layers are then closed in one layer using a 3-0 Vicryl running suture. Allis clamps are placed at either end of the median septum to facilitate the exposure (Fig. 58.3). The skin is then closed with interrupted 3-0 chromic sutures or a continuous subcuticular absorbable closure and a gauze dressing is applied. Drains are not required but can be considered if there is doubt about hemostasis. Compression or turban dressings may also be used if there is concern over postoperative hemostasis or edema.

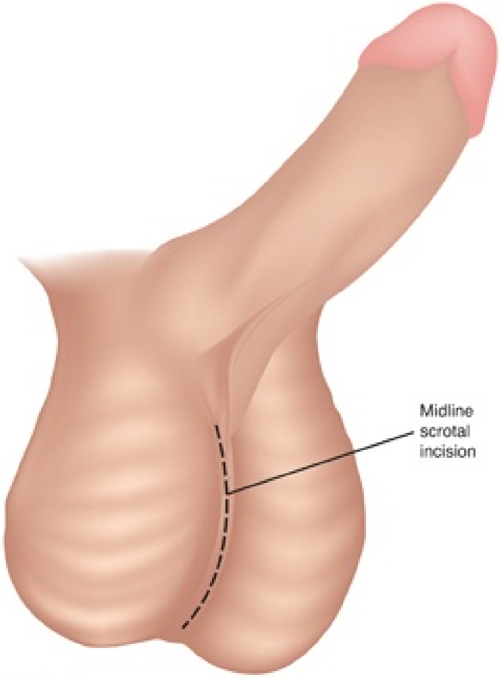

FIGURE 58.1 A midline scrotal incision over the median raphe allows access to both testes or bilateral scrotal incisions over the upper lateral scrotum is an alternative approach.

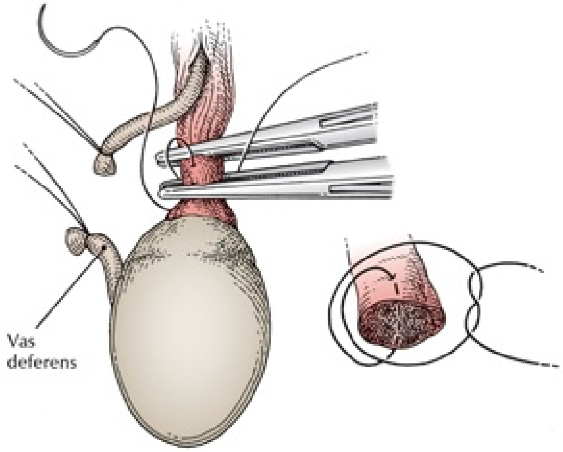

FIGURE 58.2 The vas deferens is ligated separately from the vascular structures of the cord. The vascular structures are double ligated with both a free tie proximally and a suture ligature distally using 0 Vicryl to ensure hemostasis.

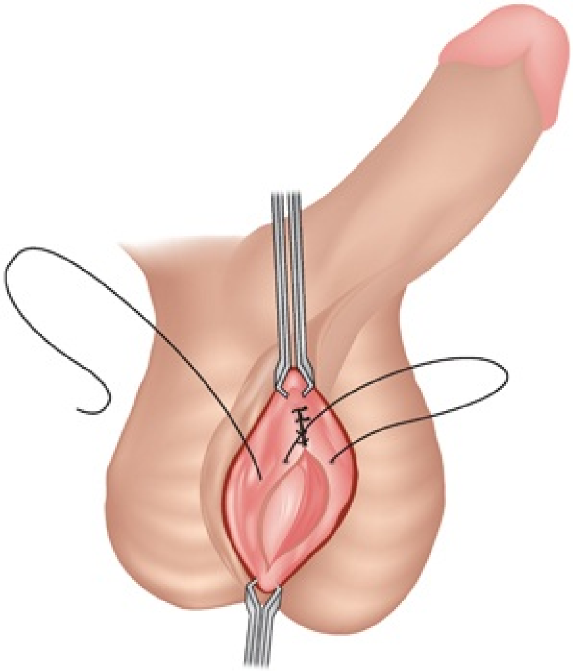

FIGURE 58.3 Closure of the deep layers of the scrotum, including the dartos musculature and testicular tunics laterally and the midline septum in one running layer.

The bilateral scrotal approach is similar except that two separate transverse scrotal incisions are made within a scrotal skin fold and between the scrotal vessels, which typically run transversely, over the upper portion of the scrotal spermatic cord (see Fig. 58.1). Manual manipulation to bring the testicle just beneath the scrotal skin in the location of the incision can help decrease the size of the incision. The incision is carried down through the tunica vaginalis and the testicle and distal cord are mobilized through the incision. The vas is separated from the surrounding cord structures, and all are clamped and divided similar to the midline approach (see Fig. 58.2). Following meticulous hemostasis, interrupted two-layer closure is performed.

Testicular prostheses are available for use in patients who desire a better cosmetic result, and these may be placed in the scrotal pouch where the testicle had been (11). Following orchiectomy, the empty scrotum is copiously irrigated with antibiotic solution and the prosthesis is inserted in the empty fossa (Fig. 58.4). Care should be taken to place the prosthesis away from the scrotal incision, which is easily avoided with either the single incision in the raphe or the lateral scrotal incisions in the upper portion of the scrotum. The prosthesis may be tacked to the skin with a suture or be allowed to be mobile; we prefer the latter because it more realistically recapitulates the normal testis.

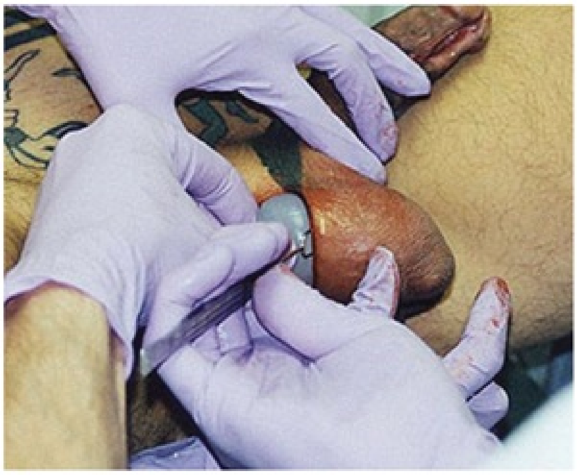

FIGURE 58.4 A placement of a testicular prosthesis into the scrotal fossa.

Suprapubic Approach

This approach is more invasive than the scrotal approach but is advantageous in patients in whom one wants to avoid a scrotal incision and/or place testicular prostheses at the time of the orchiectomy (12). The patient again is placed in the supine position and the suprapubic area is shaved. A 4- to 5-cm transverse incision is made in the midline approximately 2 to 3 cm above the pubic symphysis (Fig. 58.5). This is extended down through the subcutaneous tissues to the level of the rectus fascia using electrocautery. The subcutaneous tissue is then swept bluntly toward the external inguinal ring, exposing the distal spermatic cord, which is then isolated just distal to the ring in the upper scrotum (Fig. 58.6). Right-angle retractors are helpful to obtain exposure during this dissection by moving the incision toward the side being worked on. The spermatic cord is looped with a Penrose drain and the testicle is delivered into the wound by placing upward pressure on the scrotum and testicle, with simultaneous upward traction on the cord with the Penrose drain. The gubernaculum is then divided, which mobilizes the testicle (Fig. 58.7). The vas deferens and spermatic cord are then divided as previously described. If testicular prostheses are desired, they are then placed into the empty scrotum after adequate hemostasis is ensured, and a purse-string suture of 3-0 silk is used to close the neck of each hemiscrotum to prevent migration of the prosthesis (see Fig. 58.7). The Scarpa fascia is closed with 3-0 Vicryl suture, and the skin is closed with a 4-0 Vicryl subcuticular suture reinforced with benzoin and Steri-Strips.

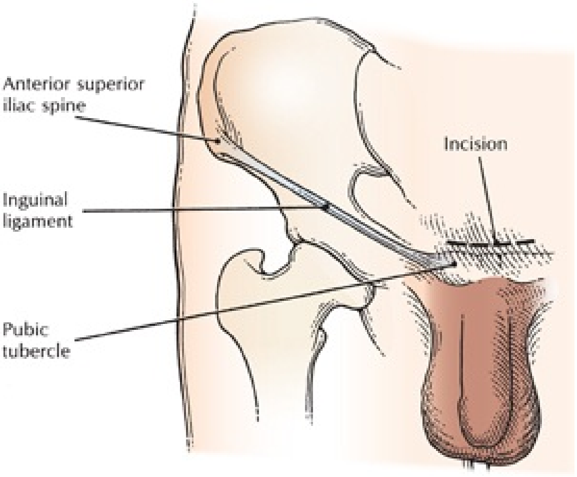

FIGURE 58.5 A midline suprapubic incision 2 to 3 cm above the pubis allows access to both testes at a level just below the external ring.

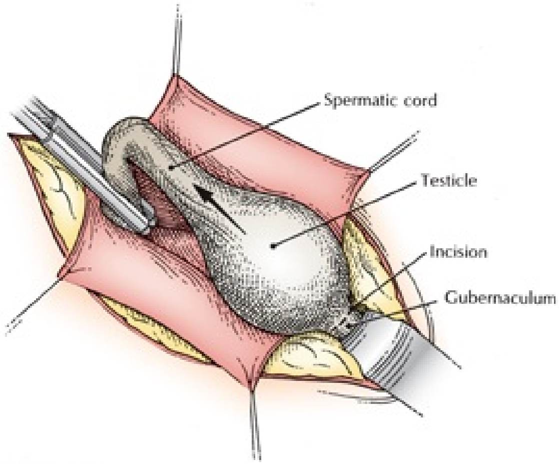

FIGURE 58.6 Isolation of the cord with a Penrose drain. Division of the gubernaculum allows complete mobilization of the testis from the scrotum.

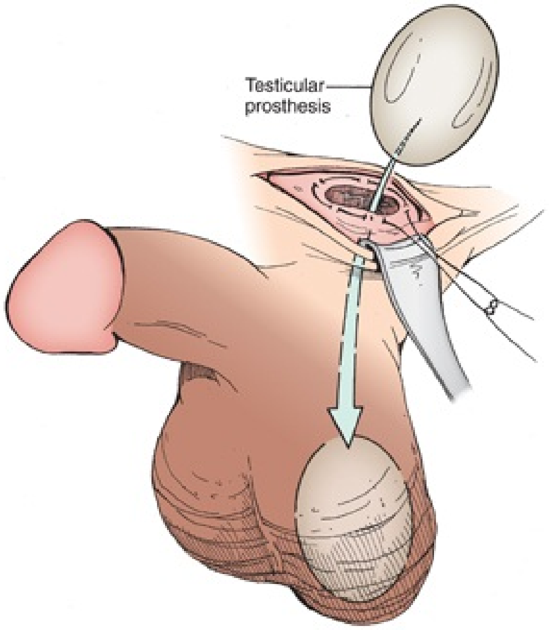

FIGURE 58.7 If a prosthesis is desired, it is placed into the empty hemiscrotum. To prevent migration, a purse-string suture is used to close the neck of the hemiscrotum, eliminating the need for an anchoring suture.

Subcapsular Orchiectomy

For patients electing orchiectomy for androgen ablation, alternatives to the total removal of the testis and epididymis have been explored and include subcapsular orchiectomy and subepididymal orchiectomy (1,13–15). These not only give the cosmetic effect of a testis being present but also achieve the therapeutic goal. There has been some controversy (16) over the efficacy of subcapsular orchiectomy since it was first described in 1942 by Riba (15); however, multiple modern studies have demonstrated its efficacy and suggest that any residual testosterone production is most likely a result of incomplete removal of the intratesticular contents (1).

The operation may be approached either through the anterior scrotum or upper lateral scrotum with two separate incisions as previously described (see Fig. 58.1). Once the testicle is delivered to the wound, the tunica albuginea is opened in midline in a cephalad-to-caudad fashion. Hemostats are placed on the edges of the capsule to provide traction, and an index finger is placed behind the capsule to invert it (Fig. 58.8). This maneuver facilitates the removal of the parenchymal contents, which are swept to the midline using a gauze sponge. The midline attachment of the parenchyma is divided using electrocautery, and the remainder of the interior capsule is cauterized to ensure hemostasis and complete destruction of all testicular parenchyma (Fig. 58.9). The tunica albuginea is then closed using a running 3-0 Vicryl suture (Fig. 58.10) and the residual testicular tunics, adnexa, and cord are returned to the scrotum. The deep layers of the scrotum are closed followed by the skin in an interrupted fashion as previously (see Fig. 58.3).

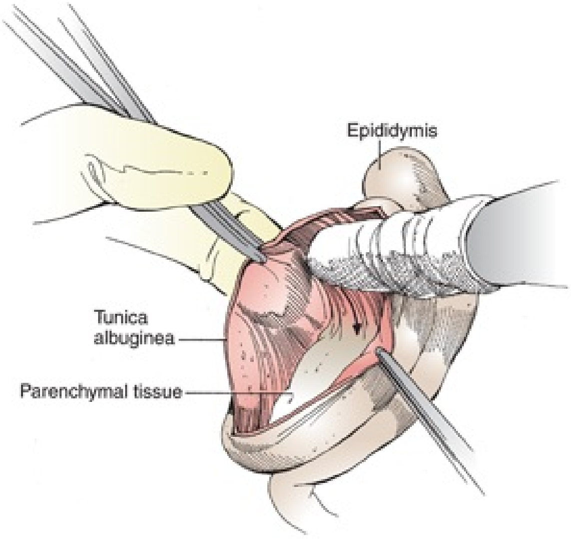

FIGURE 58.8 The tunica albuginea is opened in midline opposite the epididymis and the contents are swept bluntly to the midline attachment.

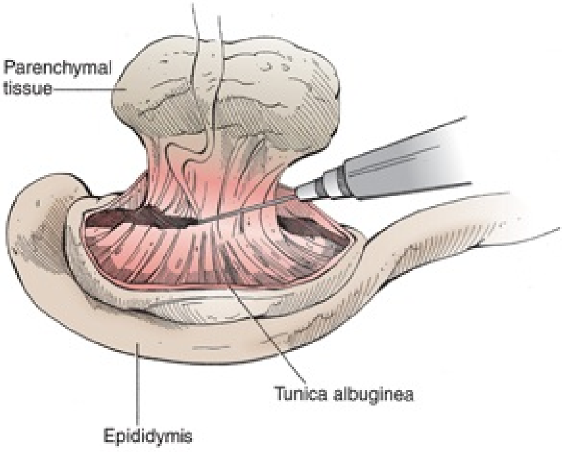

FIGURE 58.9 The parenchymal tissue is then removed at its midline attachment with electrocautery and the internal surface of the capsule is cauterized.

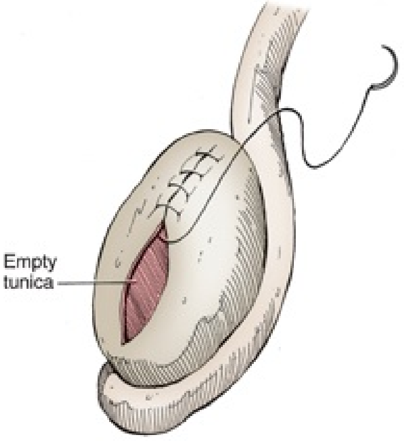

FIGURE 58.10 The tunica albuginea is reapproximated with a running 3-0 Vicryl suture.

Subepididymal Orchiectomy

Kihara and Oshima (14) have also described an epididymal-sparing orchiectomy with insertion of a pedicled fibrofatty tissue graft to preserve scrotal cosmesis after bilateral orchiectomy. This type of procedure may be complicated by epididymitis, which can be minimized by performing a vasectomy at the time of the procedure. Advantages of a fibrofatty tissue graft over implants or prostheses are that there are no risks of developing autoimmune disorders, rupture, or migration complications. However, the remnant tissue does not reapproximate the size and texture of the normal testis as well as prostheses.

Again, the initial exposure to the testicles is the same as previously described for the anterior scrotal approach (see Fig. 58.1). Once the testicle is delivered to the wound, a vasectomy is performed including double ligation and division to minimize the possibility of postoperative epididymitis (6). A line of dissection between the cleavage plane of the testis and the epididymis is utilized (Fig. 58.11). Dissection is started at the head of the epididymis, and the epididymal tissue is clamped for hemostasis. Care must be taken to secure the spermatic artery entering the testis at a point between the midportion and the tail of the epididymis. The clamped epididymal tissue is ligated using a 3-0 Vicryl suture. Meticulous hemostasis is then obtained using electrocautery, and a running 3-0 Vicryl suture on a tapered needle is used to approximate the edges of the tunica albuginea over the raw surface of the epididymis (Fig. 58.12). The remaining spermatic cord and epididymis are replaced into the scrotum, which is closed as previously described.

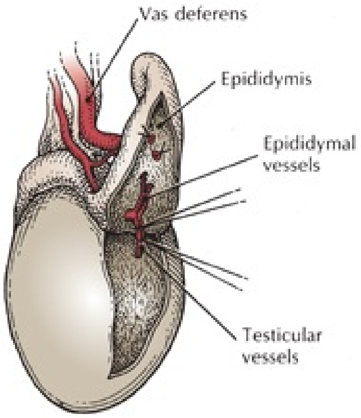

FIGURE 58.11 Dissection of the testis from the epididymis, ligating the epididymis with Vicryl suture.

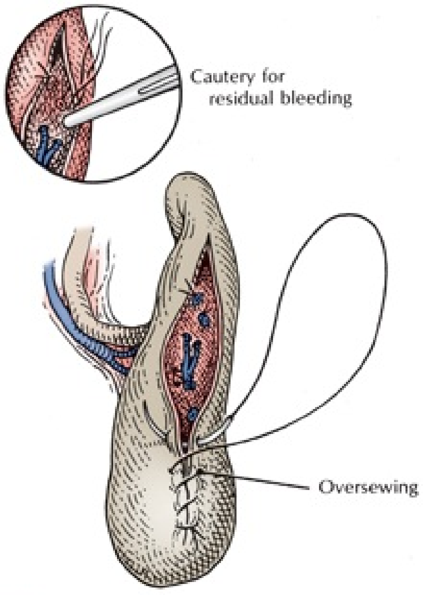

FIGURE 58.12 After removal of the testis and further hemostasis with electrocautery, the tunica of the epididymis is closed over the raw surface using a running suture.

OUTCOMES

Postoperative Care and Complications

Postoperative care similar to the procedure itself is straightforward. Analgesia with oral opioid derivatives may be required for 24 to 72 hours afterward. A sterile dressing is difficult to place over a scrotal incision and fluffs or unrolled gauze with a scrotal support is generally all that is required. Ice pack can be helpful in the immediate postoperative setting. If prosthesis or suspected infection is found, antibiotics should be continued in the postoperative setting.

Complications can include infection, edema, and the inadvertent removal of a testicular neoplasm through the scrotal approach, although the most common problem following these procedures is a scrotal hematoma. When they occur, they can be difficult but almost always resolve with conservative measures and rarely require re-exploration with evacuation of the hematoma. Several preventative measures to achieve adequate compression of the area postoperatively have been described, including turban-type dressings or compression of the scrotal wall over a gauze bolster as described by Oesterling (17). These techniques should not be substituted for obtaining meticulous hemostasis at the time of the procedure.

Infection, depending on the degree of severity, is managed by incision and drainage of any abscess pockets. This is followed by local wound care, which may include wet-to-dry dressing changes, sitz baths, and whirlpool with debridement of any devitalized tissue. Antibiotics can be used in cases where there is induration only and no abscess to drain or in combination with the incision and drainage procedure if needed. If antibiotics are used, they should be directed by the results of wound cultures.

If a testicular neoplasm has been inadvertently removed through a scrotal approach, the remaining inguinal spermatic cord should be removed as well as a wide excision of the scrotal scar. The hemiscrotum should also be removed if there was any known tumor spillage during the transscrotal procedure. This usually results in cure rates similar to those for conventional initial radical inguinal orchiectomy (18).

Results

The effectiveness of scrotal orchiectomy is dependent on the indication for the procedure. For those with metastatic prostate cancer, adequate hormonal ablation can be easily determined by measuring serum testosterone levels, which should be, castrate level within several hours after surgery (1). Prostate-specific antigen levels, patient symptoms, and patient survival may be followed to determine the procedure’s effectiveness in terms of disease control. For benign intrascrotal processes such as epididymoorchitis unresponsive to antibiotics or devitalized tissues secondary to torsion or trauma, simple orchiectomy is curative.

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CHAPTER 59 RADICAL INGUINAL ORCHIECTOMY

DANIEL J. LEE AND DOUGLAS S. SCHERR

Testicular tumors are an uncommon and clinically heterogeneous group of tumors, accounting for approximately 8,000 new cases and 370 deaths in 2013 (1) and an incidence of 5 per 100,000 men. Ninety-five percent of testicular tumors are germ cell tumors (GCTs), with the remainder consisting of gonadal stroma and secondary tumors of the testis. Approximately 90% of the GCTs arise in the testis, with 2% to 5% appearing in extragonadal regions such as the retroperitoneum and mediastinum. The survival rates for testicular cancer have improved remarkably over the past 50 years with the development of cisplatin-based chemotherapy and multidisciplinary collaboration, from 60% to 65% in the 1960s to more than 90% currently. The improvements are especially noticeable in advanced and metastatic GCT, with survival rates improving from 5% to 10% to 80% to 90% before and after the use of cisplatin-based chemotherapy. Although testicular cancer is highly curable, inappropriate management can have drastic consequences on the long-term survival and morbidity. Surgical management remains an integral part in the management of testicular cancer, although the development of improved chemotherapy options, clinical staging, and imaging modalities has changed its role. In this chapter, we will review the indications, common surgical techniques, and their associated complications for radical inguinal orchiectomy.

DIAGNOSIS

Most testicular tumors present as a painless testicular mass. Until proven otherwise, a firm intratesticular mass should be considered suspicious for cancer and worked up accordingly. The differential diagnosis of a testicular mass includes tumor, epididymitis, epididymoorchitis, torsion, and, less frequently, hernia, hydrocele, spermatocele, varicocele, hematoma, and hematocele. Acute testicular pain is less common and can be caused by rapid expansion of the testis from an intratumor hemorrhage or infarction caused by rapid tumor growth. Pain is more commonly associated with nonseminomatous GCT (NSGCT) because these tumors tend to have rapid growth and high vascularity. A significant proportion of GCT will present with metastatic disease at diagnosis, with 67% NSGCT and 15% of seminomas. However, only 10% to 20% of those with metastatic disease will be symptomatic from their metastases, with symptoms such as abdominal pain, palpable neck mass indicating supraclavicular metastasis, flank pain from ureteral obstruction, lower extremity edema from compression of the inferior vena cava, back pain from involvement of nerve roots, or dyspnea and hemoptysis from pulmonary metastasis. Approximately 2% of men will present with gynecomastia, most commonly seen in Leydig cell tumors, from elevated levels of human chorionic gonadotropin (hCG), increased estrogen, or decreased androgen production. Two-thirds of men with GCT will have decreased fertility.

Delays in Diagnosis

Delays in diagnosis of testicular cancer remain a significant problem and can have significant impact on outcomes, especially in the population of young adult males. Up to one-third of testicular cancers were found to be initially misdiagnosed as an epididymitis or hydrocele, with a median delay of 75, 101, and 134 days for stage I, II, and III, respectively (2). Even patients with metastatic disease may undergo inappropriate treatment and unnecessary surgery, as Stephenson et al. (3) reported on 40 patients who underwent an unnecessary laparotomy prior to diagnosis of a testicular mass. In a review of the literature of 4,948 testicular cancer patients, Moul (4) reported a mean duration of symptoms of 26 weeks before diagnosis.

Scrotal Ultrasound

In men with a solid testicular mass, or unexplained scrotal signs or symptoms, a scrotal ultrasound should be performed especially because it is widely available, rapid, sensitive, noninvasive, and inexpensive. Intratesticular lesions, as small as a few millimeters, can be detected with high-frequency transducers (5 to 10 Hz) with a clear delineation of anatomy. GCTs are often hypoechoic on ultrasound, with NSGCT normally with a heterogeneous echotexture, whereas seminomas tend to have a more homogenous echotexture. The incidence of bilateral GCTs is approximately 2%, so both testicles should be evaluated at each scrotal ultrasound. Testicular microlithiasis does not have a clear association with GCTs and in isolation should not prompt further evaluation (5).

Tumor Markers

Tumor markers are essential in the diagnosis, prognosis, treatment, and surveillance of testicular cancer. Testicular tumor markers, including lactate dehydrogenase, α-fetoprotein, and hCG, should be obtained at diagnosis and after orchiectomy to monitor for response to chemotherapy and to monitor for signs of recurrence.

ALTERNATIVE THERAPY

Radical inguinal orchiectomy is the standard therapy for a solid intratesticular lesion; however, partial orchiectomy may be appropriate in certain specific situations. Patients with a solitary testis or bilateral testicular masses or those with a possibility of an epidermoid cyst or benign testicular tumor may be considered for a testis-sparing procedure. The selection criteria, technique, and outcomes of testis-sparing surgery are presented elsewhere.

Sperm Cryopreservation

Sperm cryopreservation should be recommended prior to orchiectomy for all men where future fertility is a potential concern, even if the contralateral testis appears to be normal (6).

Radical Inguinal Orchiectomy

Patients suspected of having a testicular neoplasm should undergo a radical inguinal orchiectomy with removal of the tumor-bearing testis and spermatic cord up to the level of the internal inguinal ring. This procedure allows histopathologic diagnosis, tumor staging, and can provide local control of the tumor with minimal morbidity if performed appropriately.

The procedure can be performed under general, spinal, or local anesthesia on an outpatient basis. With the patient in a supine position, the lower abdominal wall, penis, and scrotum are prepped in the sterile surgical field. An oblique skin incision is made in the inguinal area along Langerhans skin lines approximately 2 cm above the pubic tubercle, extending approximately 5 to 7 cm laterally from just above the pubic tubercle (Fig. 59.1). This incision can be extended onto the upper scrotum to facilitate removal of large tumors. Camper and Scarpa fascia are incised with electrocautery to the level of the external oblique aponeurosis. A scalpel is used to make a small incision in the external oblique aponeurosis halfway between the internal and external inguinal rings. Metzenbaum scissors are then inserted into the incision with the tips closed and are pushed upward against the aponeurosis toward the external inguinal ring and then laterally toward the internal ring, so that the external oblique fascia is tented over the length of the inguinal canal to help ensure that the ilioinguinal nerve is not injured (Fig. 59.2). The opening is then incised in the direction of its fibers to the level of the inguinal ring. The ilioinguinal nerve is then identified, dissected free of the cord, and can then be retracted out of the surgical field.

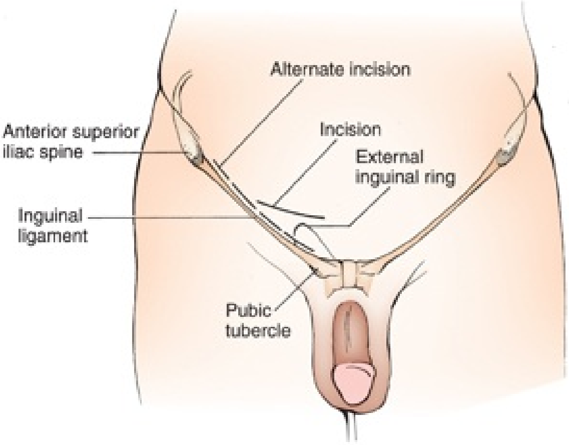

FIGURE 59.1 A 5- to 7-cm oblique skin incision is made in the inguinal area approximately 2 cm above the pubic tubercle provides adequate exposure with good cosmesis.

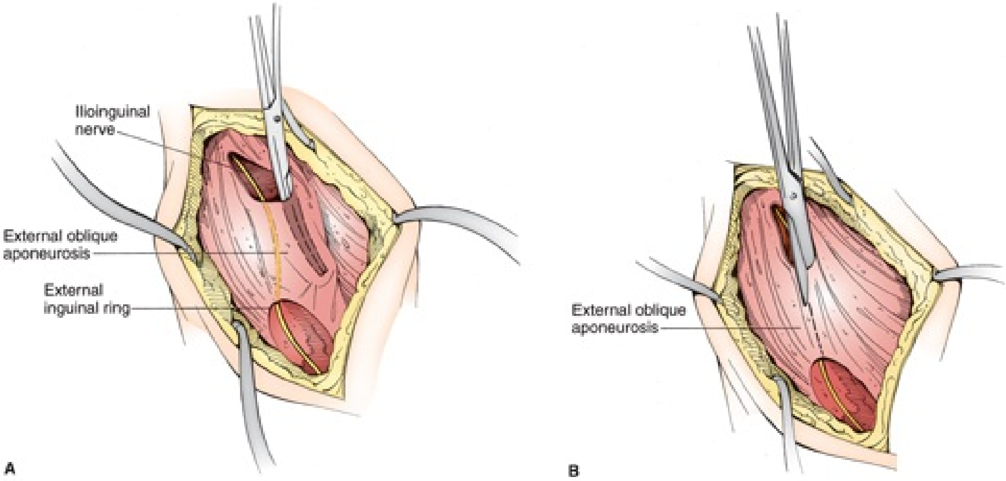

FIGURE 59.2 **A:** The external oblique fascia is tented over the length of the inguinal canal to help ensure that the ilioinguinal nerve is not injured. **B:** Using Metzenbaum scissors, the external oblique is incised and extended to the external ring.

The spermatic cord is then identified and bluntly mobilized from the inguinal ligament and floor of the inguinal canal using a finger wrapped with a gauze sponge, starting near the pubic tubercle (Fig. 59.3). The blunt dissection can be performed superiorly and inferiorly to the cord and can be facilitated using a Kittner sponge. After the spermatic cord is freed, a Penrose drain is passed around the cord. In approaching the internal ring, care should be taken to ensure that the inferior epigastric vessels are not injured. In addition, the spermatic cord should be inspected to ensure that an indirect inguinal hernia is not present. The spermatic cord is then occluded with a noncrushing clamp or a 0.5-inch Penrose drain encircled twice around the cord, tightened in a tourniquet fashion, and secured with a clamp at the level of the internal ring (Fig. 59.4).

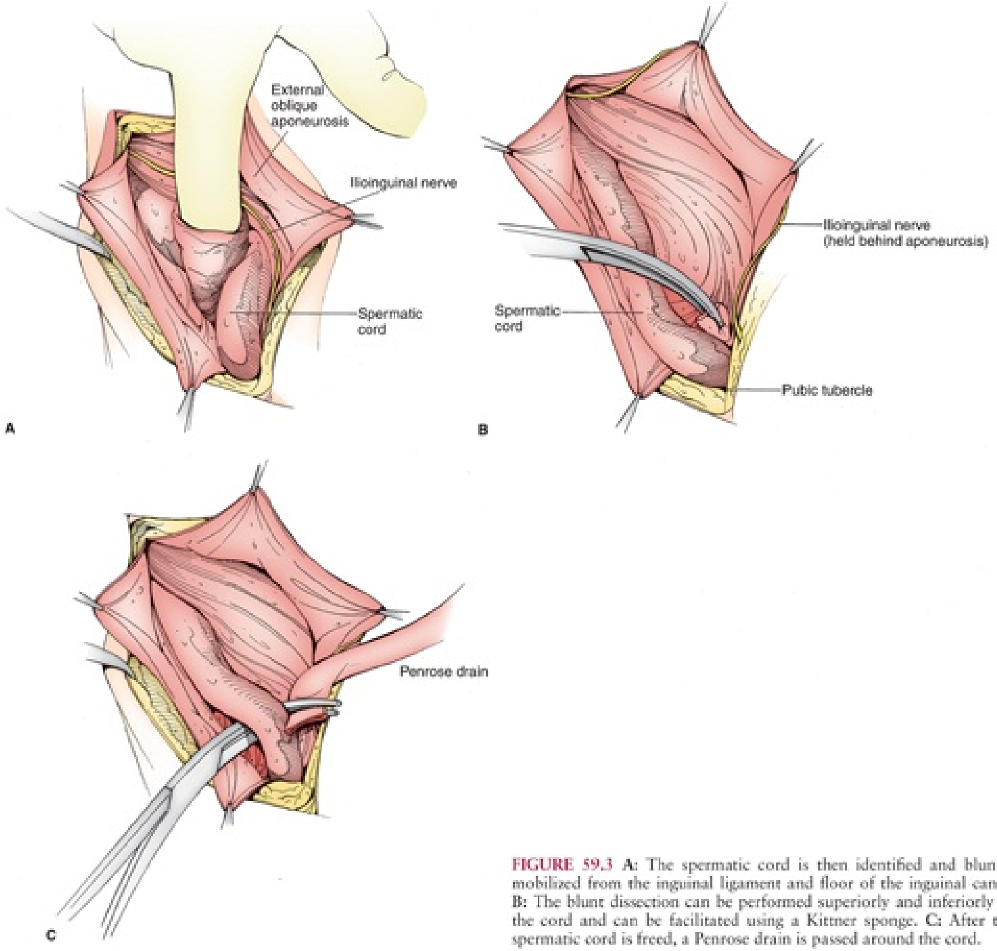

FIGURE 59.3 **A:** The spermatic cord is then identified and bluntly mobilized from the inguinal ligament and floor of the inguinal canal. **B:** The blunt dissection can be performed superiorly and inferiorly to the cord and can be facilitated using a Kittner sponge. **C:** After the spermatic cord is freed, a Penrose drain is passed around the cord.

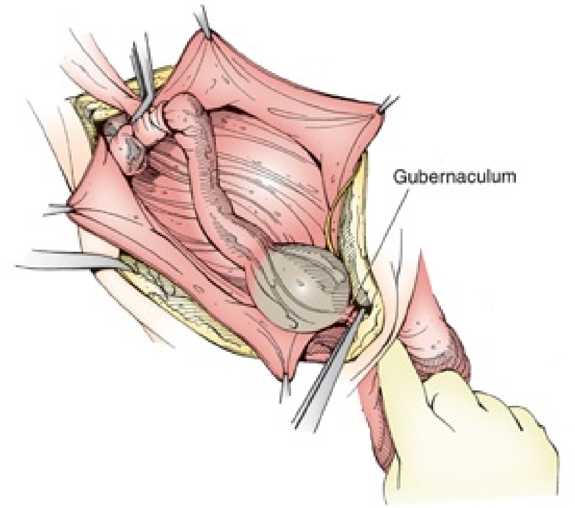

FIGURE 59.4 The spermatic cord is then occluded with a 0.5-inch Penrose drain encircled twice around the cord, tightened in a tourniquet fashion, and secured with a clamp at the level of the internal ring.

The testis can then be mobilized into a carefully draped off field by upward pressure on the external skin of the scrotum and coupled with gentle traction on the spermatic cord. The gubernacular attachments are then carefully cut using electrocautery or divided into two bundles and doubly ligated and divided, taking care not to rupture the mass or enter scrotal skin. If a diagnostic biopsy or a testis-sparing procedure is planned, the testis is cooled with saline slush; meticulous draping off is necessary before opening the tunica vaginalis and albuginea (7,8). The radical orchiectomy is completed by mobilizing the spermatic cord 1 to 2 cm inside the inguinal ring. The spermatic cord is divided into vas deferens and its vessels and internal and external spermatic vessels, which are each then double clamped at the level of the internal ring and proximal to the Penrose tourniquet with two Kelly or heavy right-angle clamps, with a third clamp occluding the cord distal to the Penrose tourniquet (Fig. 59.5). The spermatic cord is then transected and the testicle removed with the spermatic cord from the surgical field. The 0 silk ties are used to tie off the vas and its vessels and the spermatic vessels behind the most proximal clamp, and suture ligatures of 0 silk is used behind the most distal clamp. The sutures should be left long to help identify the stump of the spermatic cord if a retroperitoneal lymph node dissection (RPLND) is later performed. After the cord is securely tied off, it is allowed to retract back into the retroperitoneum. The floor of the inguinal canal and the everted scrotal wall are inspected closely to ensure that hemostasis is achieved. The wound and scrotum are then thoroughly irrigated. A testicular prosthesis can then be placed at this time or through a separate 3-cm incision in the scrotal inguinal skin fold. The ilioinguinal nerve is released, and the external oblique aponeurosis is closed with 3-0 Vicryl sutures, beginning at the level of the internal ring and extending medially as close to the pubic tubercle as possible (Fig. 59.6). The wound can be irrigated again, and Scarpa fascia can be closed with absorbable sutures. The skin incision is then closed with clips or a running subcuticular suture of 5-0 Vicryl or Monocryl. Compressive fluff dressings with a scrotal support may help minimize postoperative edema.

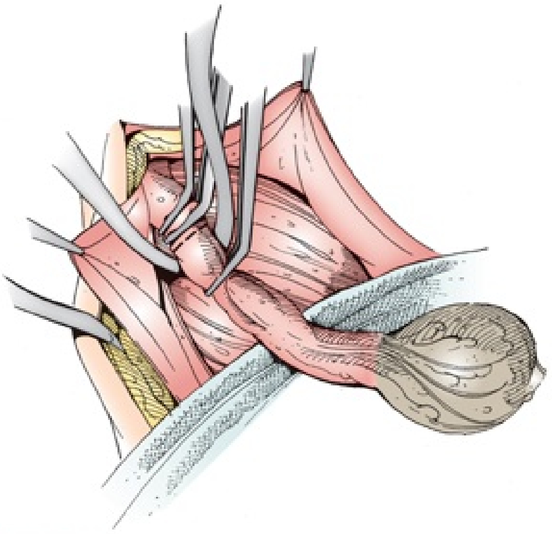

FIGURE 59.5 The spermatic cord is then double clamped at the level of the internal ring and proximal to the Penrose tourniquet with two Kelly or heavy right-angle clamps, with a third clamp occluding the cord distal to the Penrose tourniquet.

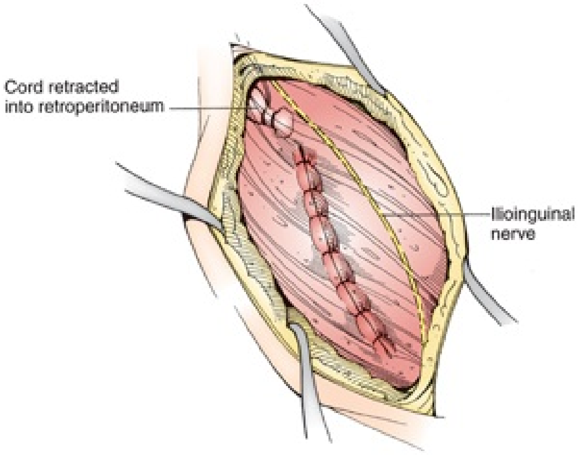

FIGURE 59.6 The stump of the cord retracts back through the internal ring into the retroperitoneum; one suture is left long. The external oblique fascia is closed with interrupted sutures placed at varying distances from the cut edge and completely closing the external ring.

COMPLICATIONS

Although complications with radical orchiectomy are infrequent, the most serious complication would be considered scrotal violation. Despite efforts to improve quality measures in the care of testicular cancer, suboptimal approaches to scrotal orchiectomy, such as scrotal orchiectomy, transscrotal biopsy, or fine needle aspiration, occur about 4% to 17% of the time (9,10). In a review of 206 cases of scrotal violation, Capelouto et al. (9) found an increased rate of local recurrence in scrotal orchiectomy compared to inguinal orchiectomy, 2.9% compared to 0.4%, respectively, but no difference in systemic recurrence or survival rates. Others have found that 11% of hemiscrotectomy specimens will have presence of tumor after scrotal violation (11). No testicular tumor should be approached transscrotally because of the risk of tumor contamination of the scrotum, risk of local recurrence, the potential for leaving spermatic cord behind, and potential alteration of lymphatic drainage of the testis. Patients with scrotal violation may benefit from the following guidelines:

- In patients with low-stage seminoma, radiation should be extended to include the ipsilateral groin and scrotum.
- In patients with low-stage NSGCT, the scrotal scar should be widely excised with the spermatic cord remnant at the time of RPLND.
- Patients who receive platinum-based regiments should have the cord stump removed at time of RPLND.

The most common complication remains postoperative bleeding, which may occasionally cause an intrascrotal or retroperitoneal hematoma. Dividing the cord into two or three bundles (vas and its vessels, internal spermatic vessels, cremaster bundle) and doubly ligating with 0 silk sutures minimizes this risk. The scrotum is an expansile organ with loose areolar tissue beneath the dermis and can allow a large hematoma to form because of a lack of tamponade. The scrotal hematoma can become quite firm, but as long as the hematoma does not become infected, it can be followed and will eventually regress. If the hematoma does become infected, it would usually require drainage. A retroperitoneal hematoma can be prevented with properly tied ligatures of the spermatic cord and care to avoid the epigastric vessels. Significant retroperitoneal hematomas can delay further therapy or be misinterpreted as metastatic disease, potentially resulting in unnecessary treatment. If the bleeding has stopped by the time it is discovered, the hematoma should ultimately be reabsorbed.

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CHAPTER 60 ORGAN-PRESERVING SURGERY IN TESTICULAR TUMORS

AXEL HEIDENREICH

Testicular germ cell tumors (TGCTs) are the most common neoplasms in young men, with bilateral simultaneous and sequential tumors arising in 2% to 3% of patients. Bilateral orchiectomy is still recommended as the gold standard treatment; it results in infertility, lifelong dependency on androgen substitution, and psychological distress due to castration at a young age. Because most testicular cancer patients are going to be longtime survivors with modern therapeutic approaches, long-term morbidity should be omitted whenever possible; cure of cancer might only be achieved if quality of life following therapy can be restored to pretreatment levels. Considering these quality-of-life issues, organ-sparing surgical approaches have been developed in patients with bilateral testicular cancer or in selected patients with a germ cell tumor arising in a solitary testicle. In addition, any patient with a testicular tumor of unknown origin should be offered organ preservation (1) even in the presence of a normal contralateral testis if testicular ultrasonography is typical for benign tumors such as simple testicular cysts (Fig. 60.1) or epidermoid cysts (Fig. 60.2).

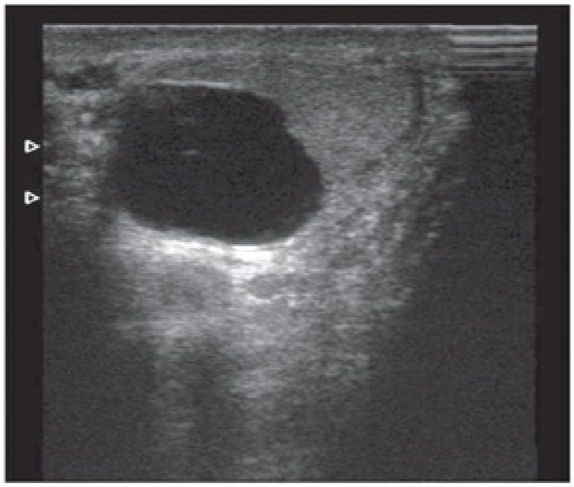

FIGURE 60.1 Ultrasound of simple testicular cysts.

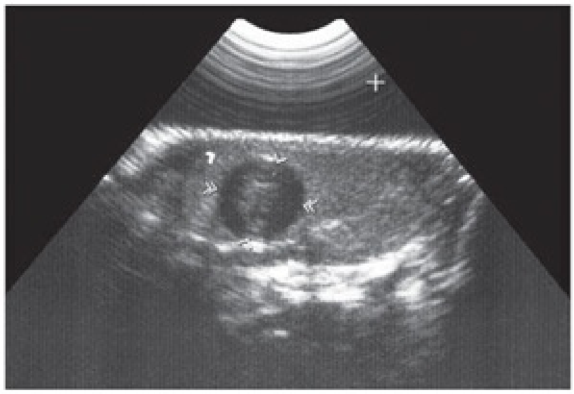

FIGURE 60.2 Ultrasound of epidermoid testicular cysts.

DIAGNOSIS

The diagnosis of testicular cancer is usually made by the appearance of a mass in the testicle that on ultrasonography appears solid or appears to have some cystic components (2). Scrotal magnetic resonance imaging appears only to be necessary if there is more than one lesion suspected or if there is a very high suspicion for a benign testicular tumor (Fig. 60.3). Serum markers, including β-human chorionic gonadotropin and α-fetoprotein, are routinely drawn prior to surgery.

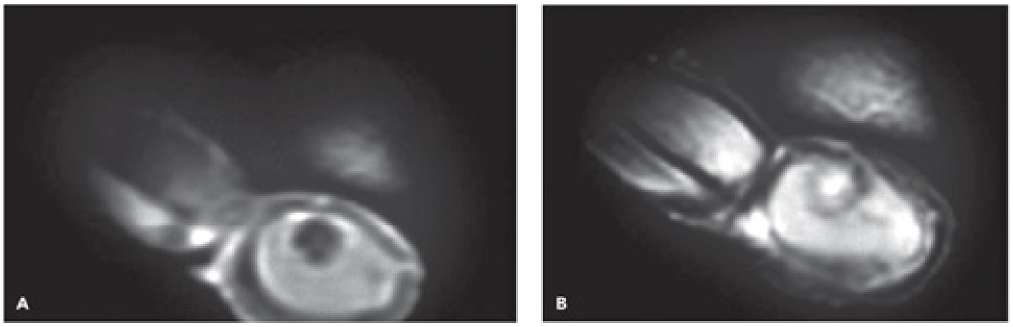

FIGURE 60.3 A and B: Scrotal magnetic resonance imaging only for very high suspicion for a benign testicular tumor.

INDICATIONS FOR SURGERY

Patients in whom preservation surgery is contemplated should have enough testicular parenchyma for maintaining physiologic testosterone synthesis, which requires that the diameter of the tumor should not exceed 2 cm (3,4). Preoperative serum testosterone and serum luteinizing hormone (LH) levels should be in the normal range. Elevated LH levels in the presence of normal testosterone levels indicate compensated Leydig cell insufficiency. These patients bear a high risk to develop hypogonadism with the need for androgen substitution following surgery. In addition, a semen analysis should be obtained to assess fertility and to discuss the option of cryopreservation (3,5). Also, testicular ultrasonography must be performed preoperatively because this usually represents the imaging modality of choice to assess the intratesticular location and diameter of the tumor. Scrotal magnetic resonance imaging appears only to be necessary if there is more than tumor suspected or if there is a very high suspicion for a benign testicular lesion (6).

ALTERNATIVE THERAPY

The alternative to testicular-sparing surgery is bilateral orchiectomy, which will require lifelong hormonal replacement. Other problems associated with bilateral orchiectomy include infertility and the psychological impact of the procedure on the patient, who is usually a young male.

SURGICAL TECHNIQUE

An inguinal approach is chosen (4) with the skin incision being made about two fingerbreadths above and parallel to the inguinal ligament (Fig. 60.4). The incision extends from the external inguinal ring cephalad for about 5 cm and is carried down to the external oblique fascia (Fig. 60.5). Care is taken not to injure the ilioinguinal nerve, which runs laterally just underneath the fascia.

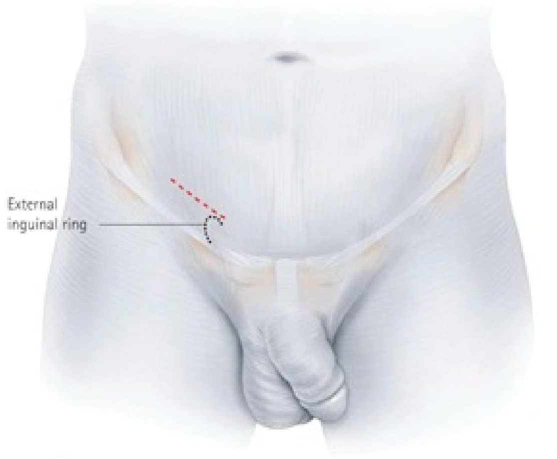

FIGURE 60.4 Inguinal incision for exploration of the testicle in relation to anatomic landmarks of the groin. (Copyright © 2012 by Jonathan Spitzer. Permission courtesy BJU International and Jonathan Spitzer, www.spitzer-illustration.com.)

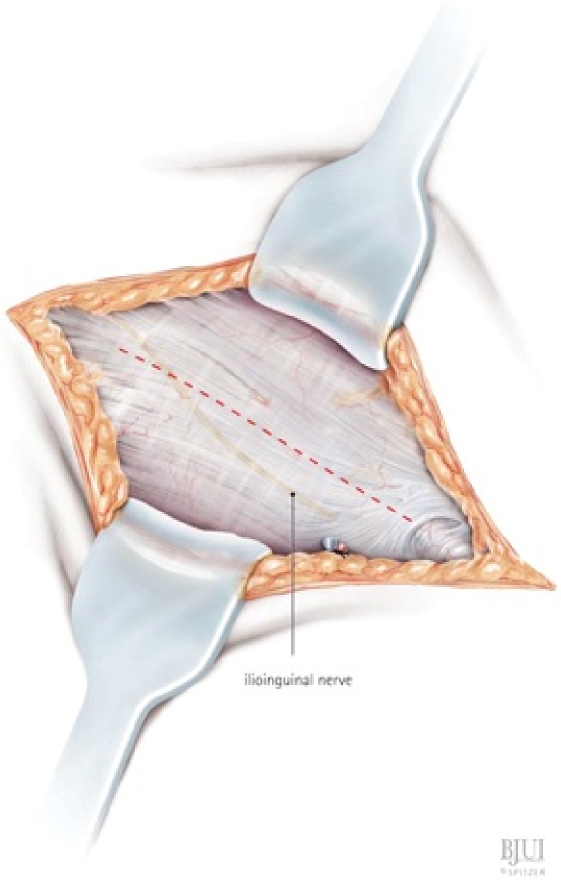

FIGURE 60.5 Incision of the external oblique fascia and its close relationship to the ilioinguinal nerve. (Copyright © 2012 by Jonathan Spitzer. Permission courtesy BJU International and Jonathan Spitzer, www.spitzer-illustration.com.)

The spermatic cord is identified and isolated at the level of the pubic tubercle (Fig. 60.6), secured with a half-inch Penrose drain, and mobilized back to the internal inguinal ring (Fig. 60.7). As in the case of radical orchiectomy, the spermatic cord might be cross-clamped with a rubber-shod clamp prior to delivering the testicle in the operating field. In this scenario, all following manipulations should be performed under cold ischemia by placing the testicle in crushed ice (1,7).

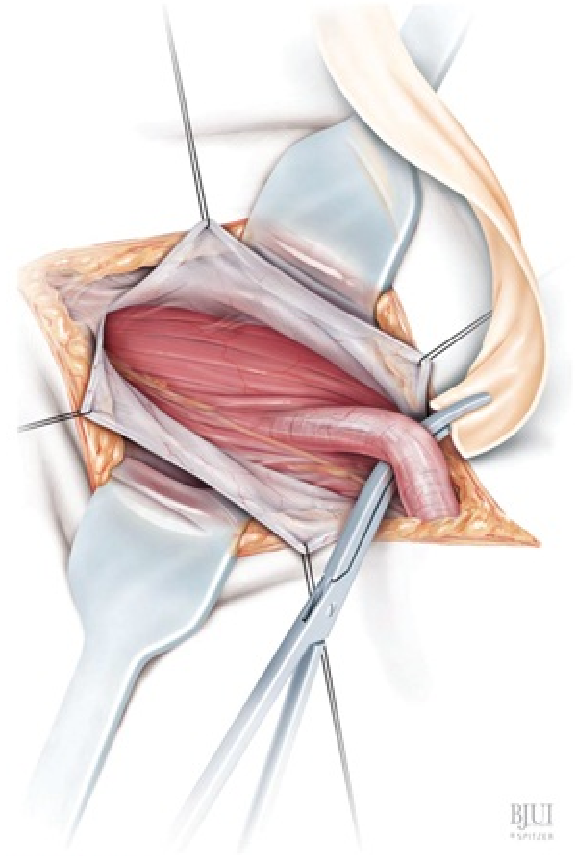

FIGURE 60.6 Delivery of the spermatic cord after the external oblique fascia has been opened. (Copyright © 2012 by Jonathan Spitzer. Permission courtesy BJU International and Jonathan Spitzer, www.spitzer-illustration.com.)

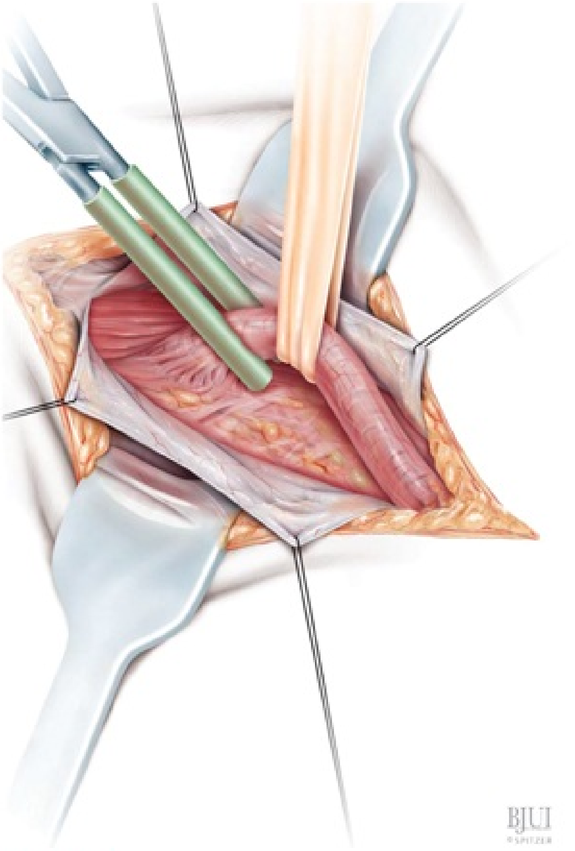

FIGURE 60.7 Mobilization of the spermatic cord up to the internal inguinal ring; the cord may be cross-clamped if desired. (Copyright © 2012 by Jonathan Spitzer. Permission courtesy BJU International and Jonathan Spitzer, www.spitzer-illustration.com.)

On the other hand, it is also possible to deliver the testicle into the operating field without cross-clamping the spermatic cord; we know that simple tumor cell shedding will not result in an increased frequency of distant metastases unless the tumor cells harbor molecular characteristics enabling them to adhere to the vascular endothelium, invade adjacent organs, and induce neovascularization. The testicle is delivered by slight traction on the spermatic cord and inversion of the scrotum; the gubernaculum is divided between two clamps and suture-ligated with 3-0 silk ties (Fig. 60.8).

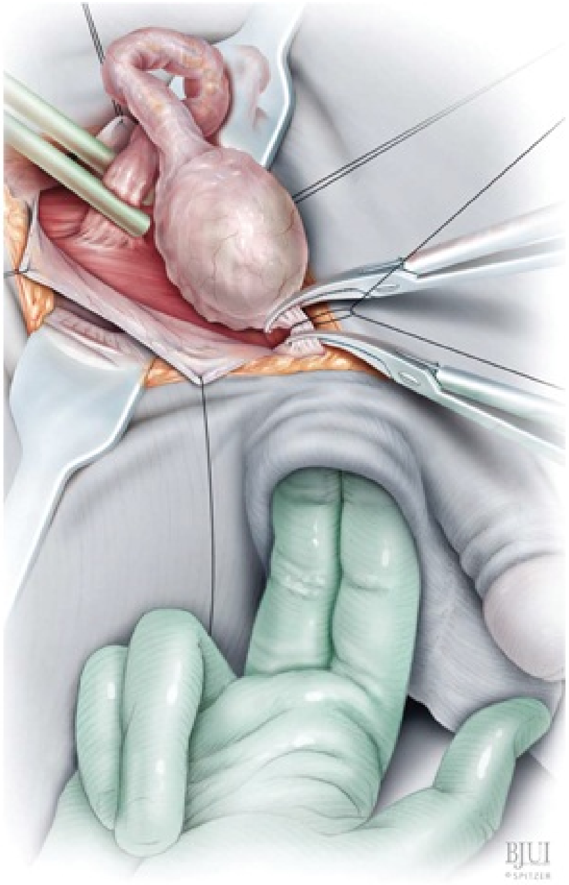

FIGURE 60.8 The testicle is delivered, and the gubernaculum may be divided and suture-ligated. (Copyright © 2012 by Jonathan Spitzer. Permission courtesy BJU International and Jonathan Spitzer, www.spitzer-illustration.com.)

The operating field is draped with laparotomy pads, and the tunica vaginalis is opened anteriorly; depending on the size and the intratesticular location of the tumor, it might be located underneath the tunica albuginea by simple palpation. In the presence of small, impalpable testicular lesions, intraoperative ultrasonography with a 7.5-MHz scanner and needle localization (7) is useful for detection (8).

The tunica albuginea is incised just above the tumor (Fig. 60.9). Use of an operating microscope under 6× to 10× magnification allows avoidance of subtunical vessels (9) and facilitates visualization of small impalpable tumors (7). Because small testicular lesions usually present with a pseudocapsule, the surrounding testicular parenchyma can be scraped away with the blade of a scalpel or a small sponge stick (Fig. 60.10). Once the tumor has been mobilized, its vascular pedicle is cauterized with a bipolar cautery and divided, and the tumor can be removed (Fig. 60.11). Following the enucleation procedure, four additional biopsies are taken from the tumor bed to exclude tumor infiltration (Fig. 60.12), and all specimens are sent for frozen-section examination (FSE). At least in our hands, FSE has turned out to represent a reliable technique to differentiate between benign and malignant tumors. Another biopsy is taken from the peripheral testicular parenchyma, fixed in Bouin or Stieve solution, and sent for pathohistologic analysis to exclude associated testicular intraepithelial neoplasia. After careful bipolar coagulation of small intratesticular blood vessels, the tunica albuginea is closed with a 4-0 Vicryl running suture (Fig. 60.13), the tunica vaginalis is closed with a Vicryl 3-0 running suture, and the testicle is replaced in the scrotum, taking care not to twist the spermatic cord. A formal orchidopexy for the testicle is not necessary. The skin is closed with an absorbable, intracutaneous running suture; usually, no drains are placed. Postoperatively, the patient should receive potent analgesics and antiphlogistics to reduce uncomfortable testicular pain.

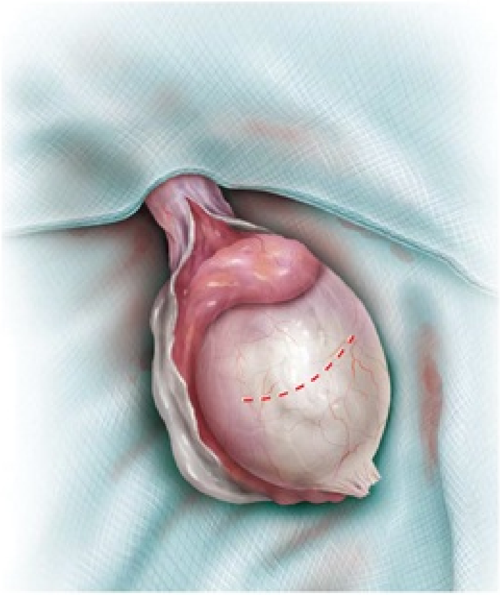

FIGURE 60.9 Incision of the tunica albuginea just above the testicular tumor. (Copyright © 2012 by Jonathan Spitzer. Permission courtesy BJU International and Jonathan Spitzer, www.spitzer-illustration.com.)

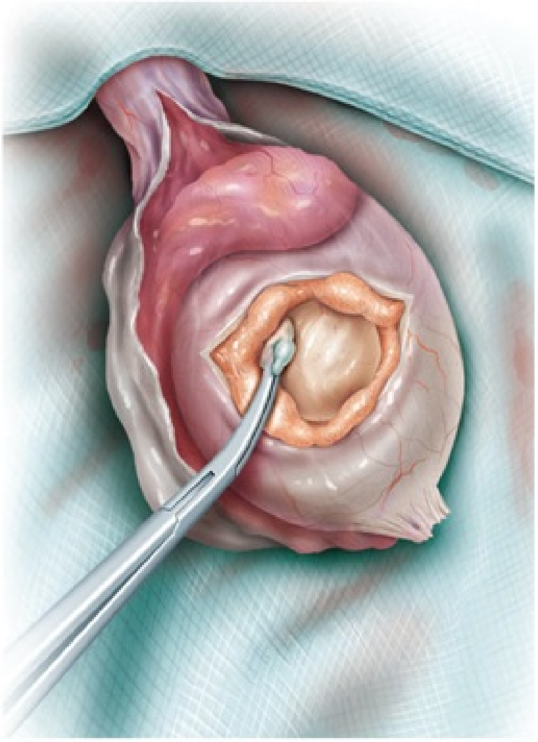

FIGURE 60.10 The tumor is surrounded by a firm pseudocapsule. (Copyright © 2012 by Jonathan Spitzer. Permission courtesy BJU International and Jonathan Spitzer, www.spitzer-illustration.com.)

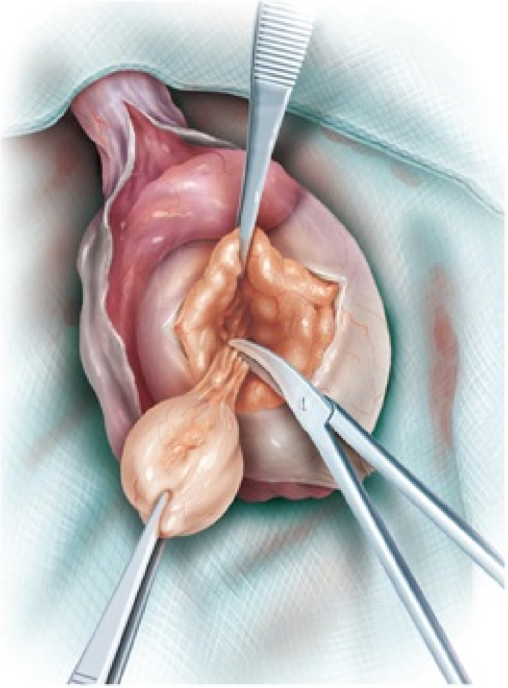

FIGURE 60.11 The testicular tumor is to be completely enucleated.

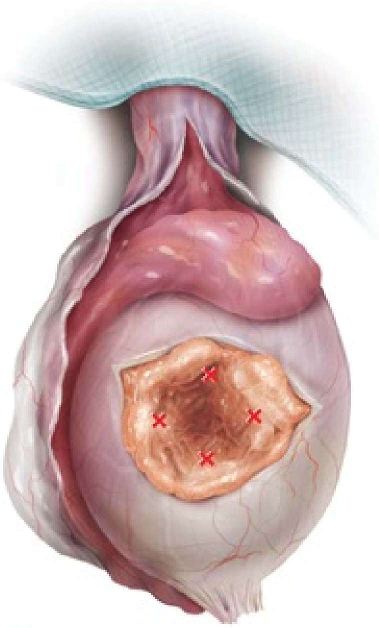

FIGURE 60.12 Additional quadrant biopsies following the enucleation procedure. (Copyright © 2012 by Jonathan Spitzer. Permission courtesy BJU International and Jonathan Spitzer, www.spitzer-illustration.com.)

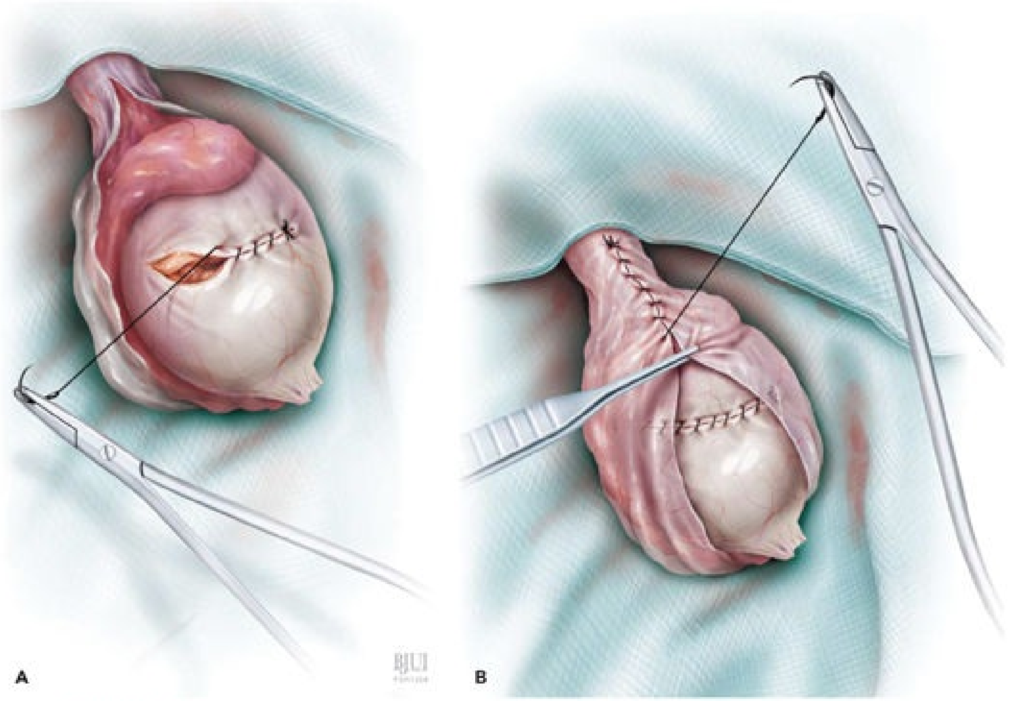

FIGURE 60.13 **A:** Running suture of the tunica albuginea. **B:** The testis is replaced in the scrotum, and the fascia closed with polyglactin 2-0; subcutaneous tissue is closed by a running suture with polyglactin 3-0, and the skin closed by an intracutaneous running suture with polyglecaprone 3-0. (Copyright © 2012 by Jonathan Spitzer. Permission courtesy BJU International and Jonathan Spitzer, www.spitzer-illustration.com.)

OUTCOMES

Complications

Potential complications include hemorrhage and loss of the testicle. Eighty-five percent to 92% of patients have maintained adequate androgen levels (5).

Results

The initial study with a limited number of patients showed a 5-year survival rate of 92% and the maintenance of physiologic testosterone serum levels in 92% without the need for androgen substitution (5). These findings resulted in the German Testicular Cancer Study Group criteria for proper patient selection, surgical technique, and follow-up based on the review of a large patient cohort with a median follow-up of >8 years. The disease-free survival rate was 99%, local recurrences developed in 5.5%, and normal testosterone serum levels were maintained in 85% of the patients.

The use of testicular-sparing surgery in testicular cancer requires that there be close follow-up for possible recurrence. The best modality for local follow-up is transscrotal ultrasonography. We recommend the first ultrasound to be done 4 to 6 weeks postoperatively, a time when scar tissue has replaced the intraparenchymatous traumatic edema; thereafter, scrotal imaging should be performed at 2-month intervals for the first year to adequately document the developing scar tissue for further follow-up studies (5). In patients who have undergone local radiation therapy postoperatively, periodic ultrasonography can be safely omitted and the patients should be educated to self-palpate the testicle. In patients who have not undergone adjuvant local radiation, periodic ultrasonography should be performed twice annually due to the high risk of local recurrence. In patients who develop a local recurrence, secondary orchiectomy has to be performed and androgen substitution has to be initiated

(3,5,10).

In summary, organ-preserving surgery in patients with TGCTs is feasible in patients with bilateral testis cancer or germ cell tumor in a solitary testicle. The procedure should be performed in conjunction with biopsies of the tumor bed and the resection rim and frozen-section analysis as well as a biopsy of the peripheral parenchyma. Follow-up in these patients should be either postoperative radiation of the remaining testicle with 18 Gy or very close follow-up. As this is still a controversial procedure, it may be best performed in a center experienced in the management of testicular cancer.

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CHAPTER 61 RETROPERITONEAL LYMPH NODE DISSECTION

SIMON KIMM AND JOEL SHEINFELD

The contemporary management of testicular germ cell tumors (GCTs), which incorporates significant advances in imaging, surgery, chemotherapy, and radiation therapy, has achieved high cure rates for this disease. But optimal outcomes for individual patients are highly dependent on nuances of management, underscoring the great importance of delivering the appropriate therapy, properly, and in the correct sequence (1). Failures of accurate staging, disciplined surveillance, and optimal treatment can lead to compromised chances for cure, long-term morbidity, and death.

Retroperitoneal lymph node dissection (RPLND) plays a key role in the management of testis cancer. When performed appropriately, it provides invaluable staging information, critical insight into tumor biology, and eradicates primary, chemorefractory, and potential sources of secondary cancers. Staging and prognostic information can be obtained through RPLND that exceed that of current imaging modalities. Standard axial imaging with computerized tomography (CT) or magnetic resonance imaging (MRI) understages 20% to 25% of patients with clinical stage (CS) I and overstages 15% to 35% of patients with CS IIA nonseminomatous germ cell tumor (NSGCT) (2,3). RPLND also plays a critical role as a therapeutic modality. In patients with low-stage NSGCT, cure rates approach 99% (4–6). In cases where the burden of retroperitoneal disease is low (pN1), RPLND monotherapy achieves cure in 90% of cases without additional chemotherapy, reduces the risk of retroperitoneal relapses to <2%, and reduces the burden of routine surveillance imaging (6,7). Although cure rates decline to <50% when RPLND is performed for higher volume disease (pN2), two cycles of adjuvant chemotherapy increases the cure rate to >98% (6,8,9). Suboptimal RPLND can result in increased relapse rates, late relapses, reoperative surgery, and decreased survival rates (10–12). Patients who must undergo reoperative retroperitoneal surgery after incomplete initial resections pay a particularly high price. After primary RPLND, reoperative RPLND leads to a 5-year disease-specific survival decrease from 99% to 86% (10). In the postchemotherapy setting, the 5-year disease-specific survival falls from 90% to 56% for patients requiring reoperative surgery (10).

RETROPERITONEAL LYMPH NODE DISSECTION BOUNDARIES

Most GCTs spread lymphatogenously in a predictable sequence from their sites of origin in the testis. Metastases usually occur in well-defined regions of lymph nodes in the retroperitoneum, subsequently progressing to thoracic sites in the lung, posterior mediastinum, and then to involve distant visceral organs (13). Distant metastases, without concomitant retroperitoneal disease, are rare (6). The contemporary understanding of testicular lymphatic drainage was established by important RPLND mapping studies performed by Donohue et al. (14), Weissbach and Boedefeld (15), and Ray et al. (13). Anatomic regions were described along with the most common landing zones for tumors that arise from the left or right testicle (Fig. 61.1). Right-sided testicular tumors disseminate initially to the interaortocaval, precaval, and preaortic nodal groups and have the ability to spread to contralateral lymphatic sites (13,16,17). The landing zone of left-sided tumors includes the para-aortic and preaortic lymph nodes, with a low incidence of contralateral spread (13,6,15,16).

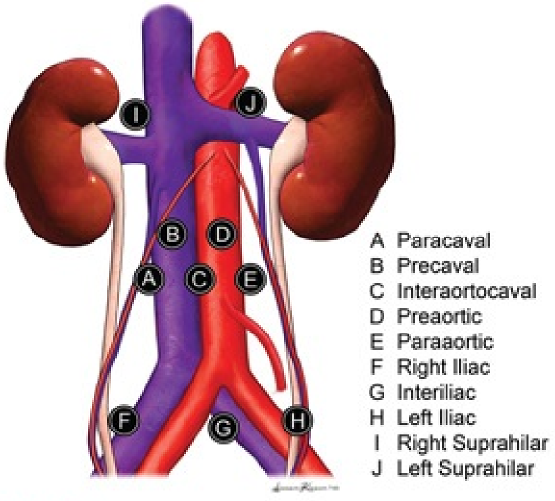

FIGURE 61.1 Anatomic regions of the retroperitoneal lymph nodes.

The standard bilateral RPLND includes the following boundaries: the renal vessels superiorly, the ureters laterally, the bifurcation of the iliac vessels inferiorly, and the prevertebral and psoas fascia posteriorly (Fig. 61.2). Although the early development of the RPLND included dissection of the suprahilar lymph nodes bilaterally, this has been shown to significantly increase chylous ascites and renovascular and pancreatic complications, with minimal oncologic benefit (4). Given the improvements in imaging, this element of the dissection is now omitted, except where known suprahilar disease exists in the postchemotherapy setting. Suprahilar metastases do occur, with the most common site of involvement the nodes of the retrocrural space (18).

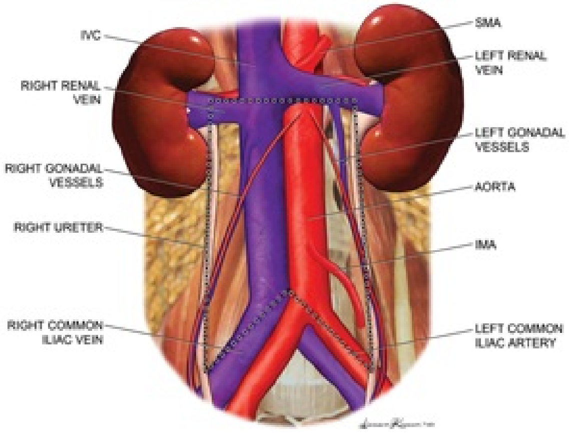

FIGURE 61.2 Boundaries of full-template RPLND. The renal vessels form the superior boundary, the ureters form the lateral boundary, and the bifurcation of the iliac vessels forms the inferior boundary. *IMA*, inferior mesenteric artery; *IVC*, inferior vena cava; *SMA*, superior mesenteric artery.

ANTEGRADE EJACULATION

Disruption of autonomic nerves in the retroperitoneum can lead to the loss of antegrade ejaculation, a complication that was noted in up to 90% of patients early in the development of the RPLND (19). The paired sympathetic chains along with their sympathetic ganglia, the postganglionic sympathetic fibers from T2 to L4, and the hypogastric plexus are essential in the process of seminal emission (Fig. 61.3). To decrease the risk of ejaculatory dysfunction, modified RPLND templates were developed based on retroperitoneal mapping studies (1,13,6,20,21). These templates altered the boundaries of the standard bilateral RPLND to minimize disruption to the hypogastric plexus and contralateral postganglionic sympathetic nerves below the inferior mesenteric artery (IMA) (Fig. 61.4). Although early reports suggested sustained oncologic outcomes, more recent studies reveal that modified template dissections could potentially miss a significant proportion of retroperitoneal metastatic disease. In a cohort of 500 patients with CS I or IIA NSGCT who underwent primary RPLND at Memorial Sloan-Kettering Cancer Center, the distribution of positive lymph nodes was analyzed and compared using five different modified template schemes (22). Depending on the template applied, 3% to 23% of metastases would be missed if a modified template was used (20). Moreover, 56% of these patients received adjuvant chemotherapy, which may have masked unresected disease and led to underestimation of the true rate of extratemplate disease. If all patients underwent full bilateral template resection, the rate of unresected disease would fall to below 3% (22,23). In a similar study of 269 patients who underwent postchemotherapy RPLND (PC-RPLND) for advanced disease, 7% to 32% of patients harbored extratemplate disease (24). These reports support the use of full, bilateral, infrahilar RPLND and suggest modified templates may inadequately treat the retroperitoneum. This leads to an increased burden of postsurgery surveillance, higher rates of postsurgery chemotherapy, and inferior long-term oncologic outcomes (21,23).

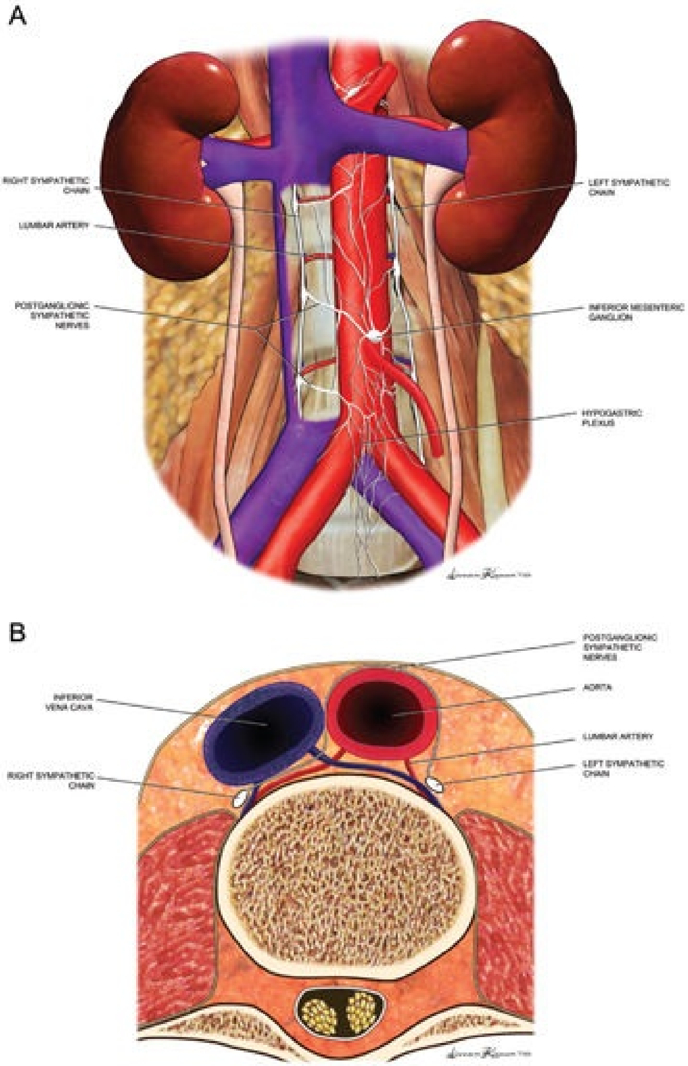

FIGURE 61.3 Schematic of retroperitoneal nerves. **A:** The sympathetic fibers innervating responsible for seminal emission emerge as postganglionic fibers from T12 to L3. The paired sympathetic trunks lie on the medial borders of the psoas muscle bilaterally. Fibers converge on the anterior surface of the aorta to form the inferior mesenteric and hypogastric plexuses. **B:** The right sympathetic trunk lies posterior to the IVC, and the left sympathetic trunk lies near the lateral border of the aorta. The lumbar branches of the great vessels run closely with the nerves and course medial to the sympathetic trunks as they course toward the vertebral foramina.

NERVE-SPARING RETROPERITONEAL LYMPH NODE DISSECTION

With advancements in the understanding of the neuroanatomic basis of seminal emission and ejaculation, critical nerves can be prospectively identified and spared without compromising the boundaries of resection. Each vas deferens and seminal vesicle is innervated by postganglionic sympathetic nerve fibers arising from the sympathetic chain from T12 to L3. The right sympathetic chain lies directly posterior to the inferior vena cava (IVC), whereas the left sympathetic chain lies posterior to the lateral border of the aorta (see Fig. 61.4B).

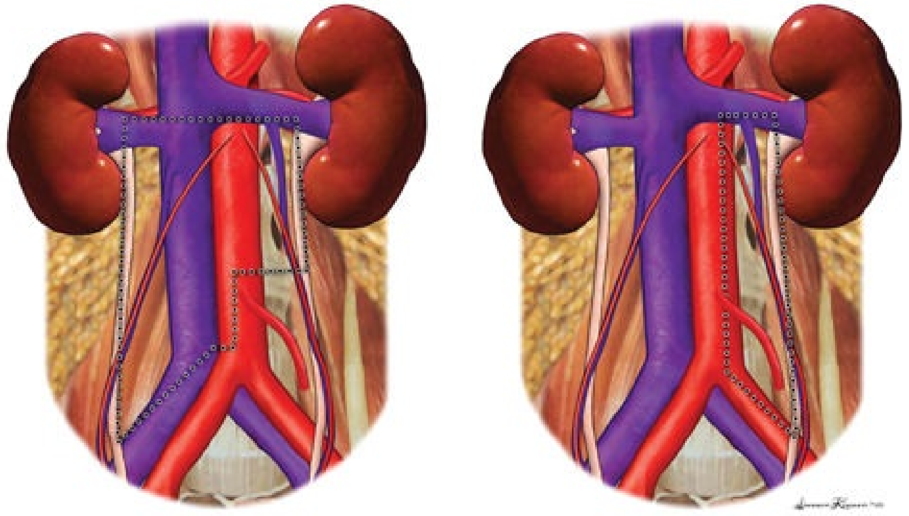

FIGURE 61.4 Right and left modified templates for RPLND. Several side-specific modified templates for patients with low-stage NSGCT have been proposed, with each including ipsilateral lymph nodes inferior to the renal hilum extending to the bifurcation of the iliac arteries. Right-sided templates include the interaortocaval region, and both avoid dissection below the contralateral IMA.

The postganglionic fibers emerge anterolateral to the lumbar vessels, from the lumbar foramina. The lumbar vessels emerge medial to the sympathetic trunks. Nerves from the right sympathetic trunk course from the medial border of the IVC anterolaterally over the aorta and converge with fibers from the left sympathetic trunk to form the plexus of nerves on the anterior surface of the aorta, including the hypogastric plexus. Due to this anatomic arrangement, dissection of the lymph nodes over the aorta, or the *anterior aortic split*, should be performed after the nerve fibers have been identified and isolated to prevent their unintended disruption (Fig. 61.5). After meticulous dissection, the sympathetic chains, the postganglionic sympathetic fibers, and the hypogastric plexus are preserved. This approach has yielded a postoperative return to antegrade ejaculation in 95% of patients undergoing primary RPLND and 79% in postchemotherapy RPLND (25–28).

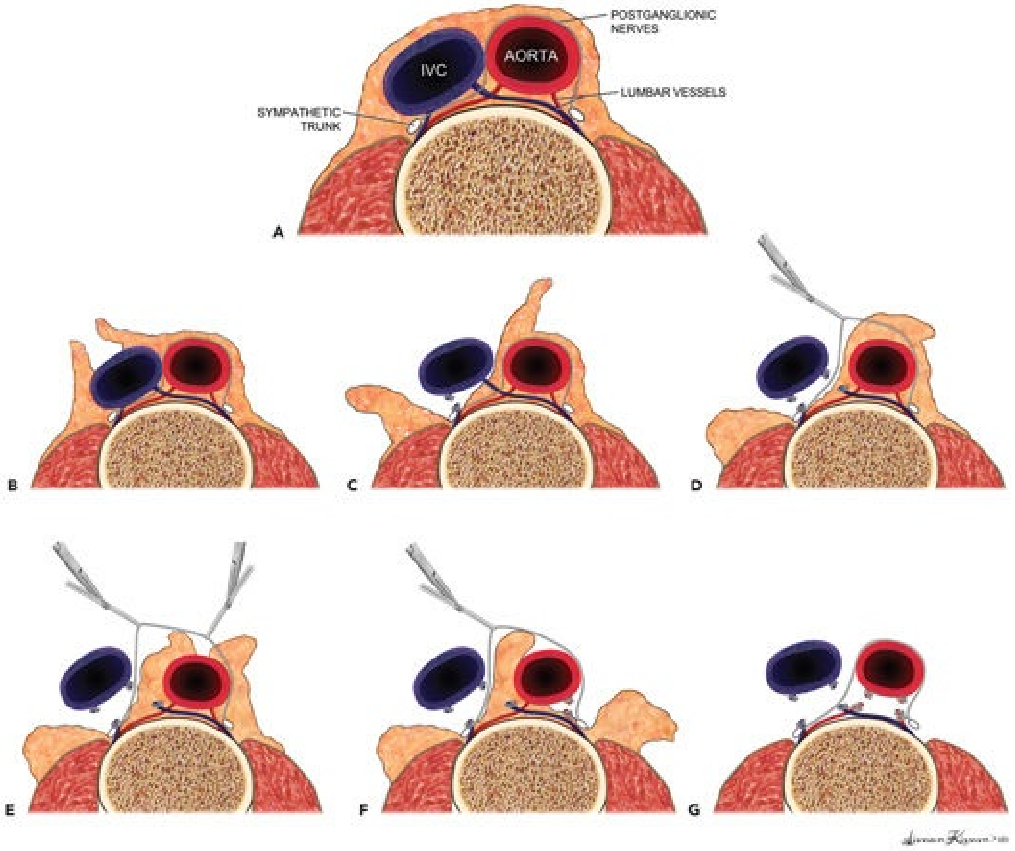

FIGURE 61.5 Split-and-roll technique of nerve-sparing retroperitoneal lymphadenectomy. **A:** The cross-sectional anatomy of the lymphadenectomy specimen. The split-and-roll technique is used to safely remove the specimen en bloc. **B:** The dissection begins with a "split" above the IVC. **C:** The sympathetic trunk is exposed, and the lumbar vessels are controlled near their insertion at the IVC and near the vertebral foramina. **D:** The postganglionic sympathetic nerves are prospectively identified and tagged with vessel loops. **E:** The anterior aortic split is made while protecting the sympathetic nerves. **F:** The para-aortic, preaortic, and interaortocaval lymph nodes are freed and lumbar vessels controlled and ligated. **G:** The specimen is removed en bloc with the posterior boundary marked by the psoas fascia and anterior spinous ligament. *IVC*, inferior vena cava.

SPERM CRYOPRESERVATION

Because even nerve-sparing RPLND does not guarantee preservation of antegrade ejaculation and because intraoperative findings may preclude a nerve-sparing procedure, all men in whom future fertility is a potential concern should be encouraged to cryopreserve sperm preoperatively (29).

Preoperative Preparation

Prior to surgery, patients should have up-to-date staging with a contrast-enhanced abdominopelvic CT or MRI within 4 to 6 weeks. These images are essential for surgical planning and should be evaluated for the extent of disease and the anatomy of the vessels and ureters. Variations and abnormal vascular anatomy is noted in approximately 20% of patients, such as accessory renal arteries or retroaortic left renal veins. Retroaortic renal vessels are easily misidentified and may be inadvertently divided, as they often resemble lumbar branches of the IVC. Partially and completely duplicated ureters must also be identified preoperatively. Serum tumor markers are ideally measured 7 to 10 days before surgery to ensure accurate staging. A high-fat diet is recommended for 2 days prior to surgery, which results in a milky white chyle that improves the visibility of retroperitoneal lymphatics and clipping of leaking lymphatic channels.

Perioperative Preparation

One hour prior to the initial incision, antibiotic prophylaxis is provided with a first-generation cephalosporin. General endotracheal anesthesia is induced with neuromuscular paralytics. Sequential compression devices are placed for deep vein thrombosis (DVT) prophylaxis. A Foley catheter is placed and connected to closed drainage. A nasogastric or orogastric tube is placed and low continuous suction initiated. The frame of the Gallagher retractor, which provides controlled exposure of the duodenum and pancreas, is attached to the surgical table. The skin of the chest, abdomen, and pubis is prepped and draped using sterile technique.

SURGICAL TECHNIQUE

Incision

The midline abdominal incision is the standard approach to RPLND. In certain situations, a thoracoabdominal incision may offer certain advantages if dissection above the renal vessels, thoracic cavity, or mediastinum is required (30). A scalpel is used to incise the dermis, with the incision extending from the xiphoid process to the symphysis pubis in the midline with a leftward deviation around the umbilicus (Fig. 61.6). The electrocautery is used to carry the incision through the subcutaneous tissue to the anterior rectus fascia. The fascia is cleared of fat and overlying tissue on either side of the linea alba to facilitate closure at the end of the case.

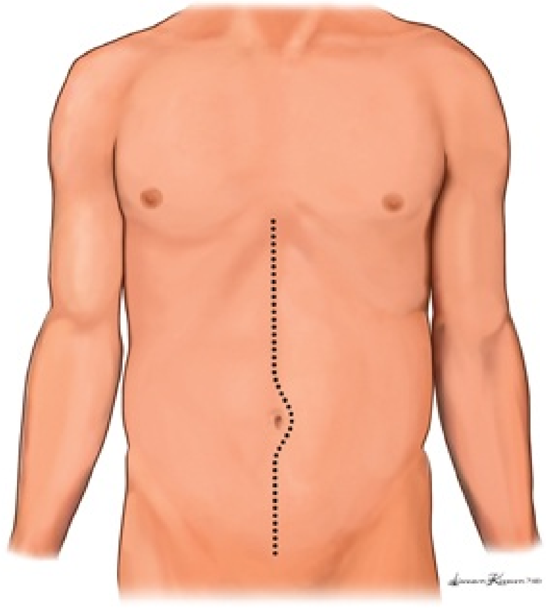

FIGURE 61.6 Incision. The standard approach is through an anterior abdominal wall incision extending from the xiphoid process to the symphysis pubis.

The peritoneum is sharply incised and opened. The falciform ligament is ligated with 0 silk ties, divided, and the distal segment excised from the anterior abdominal wall with the properitoneal fat. Complete removal allows for upward retraction of the liver without tension on the liver capsule, preventing a tear. Two Balfour self-retaining retractors are used for exposure. The crossbar of each is padded with a folded towel. The greater omentum and transverse colon are reflected cranially and out of the abdomen onto moist laparotomy pads on the patient’s chest (Fig. 61.7). Careful intraperitoneal exploration is performed to assess for evidence of visceral metastases. The position of the nasogastric or orogastric tube is confirmed.

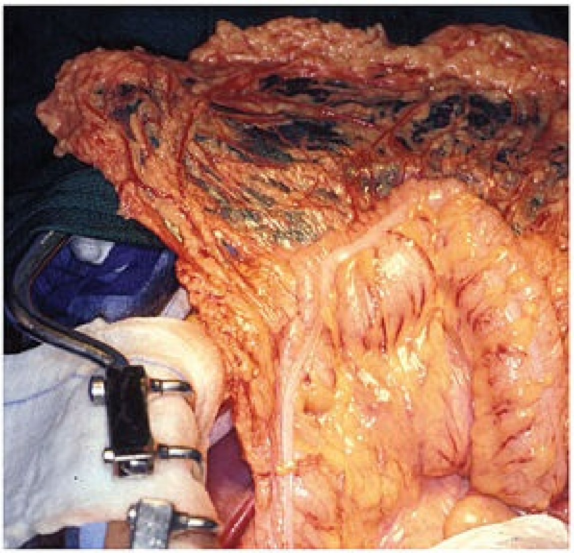

FIGURE 61.7 Reflection of the transverse colon and omentum. Care is taken to avoid traction injuries, and all structures are wrapped in saline soaked laparotomy pads and resting on towels.

Exposure of the Retroperitoneum

The root of the mesentery exposed by reflecting the small bowel superiorly and laterally. An incision is made in the posterior parietal peritoneum medial to the inferior mesenteric vein, extending from the ligament of Treitz down to the ileocecum carefully with the electrocautery. The peritoneal incision is then extended superiorly along the right white line of Toldt to mobilize the ascending colon (Fig. 61.8). Careful cephalad reflection of the small bowel and colon is performed, with the right gonadal vein serving as a landmark for the correct, avascular plane of dissection.

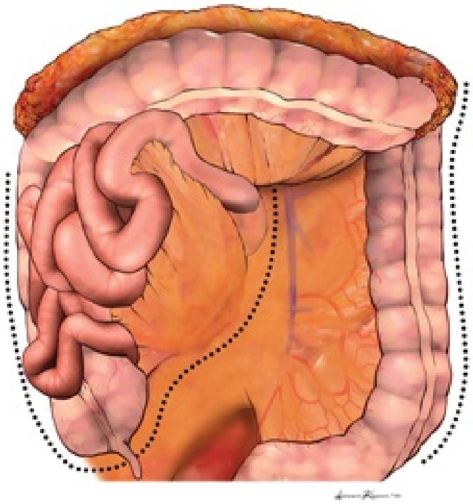

FIGURE 61.8 Posterior peritoneal incisions. Access to the retroperitoneum is achieved by extending an incision in the posterior peritoneum from the ligament of Treitz along the root of the mesentery to the ileocecal region. The IMV serves as an important landmark as this structure defines the left leaf of the posterior peritoneum. The line of Toldt on both sides mobilizes the ascending and descending colon.

A Kocher maneuver is used to mobilize the fourth segment of the duodenum and pancreas (Fig. 61.9). The undersurface of these structures are rich in lymphatic vessels, which must be meticulously clipped and divided (Fig. 61.10A). Electrosurgical dissection is avoided. Lymphatic vessel visualization is improved by a preoperative high-fat diet, which also helps to declare lymphatic leakage of chyle. The ultimate goal of this part of the dissection is exposure of the left renal vein, marking the superior border of the dissection on the left side (Fig. 61.10B). An important avascular plane of dissection is developed toward the left between the inferior mesenteric vein (IMV) and the left gonadal vein (Fig. 61.11). A thick condensation of lymphatics in this region is clipped and released to improve mobility and reduce traction to the distal pancreas. The undersurfaces of the pancreas and duodenum are held by connective tissue that is rich in lymphatics and must be controlled to prevent significant lymphatic leakage. These channels must be meticulously clipped prior to division (Fig. 61.12). Larger groups of lymphatic channels are ligated with 3-0 silk ties.

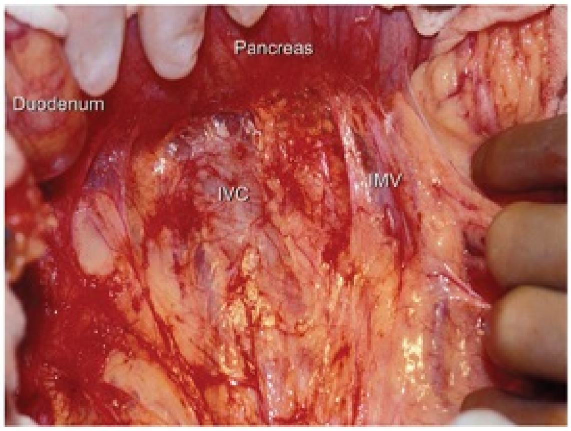

FIGURE 61.9 A Kocher maneuver is used to free the duodenum and pancreas, revealing the underlying great vessels and providing access to the superior border of the dissection. The second, third, and fourth segments of the duodenum and pancreas are reflected upward and out onto the chest wall. *IMV*, inferior mesenteric vein; *IVC*, inferior vena cava.

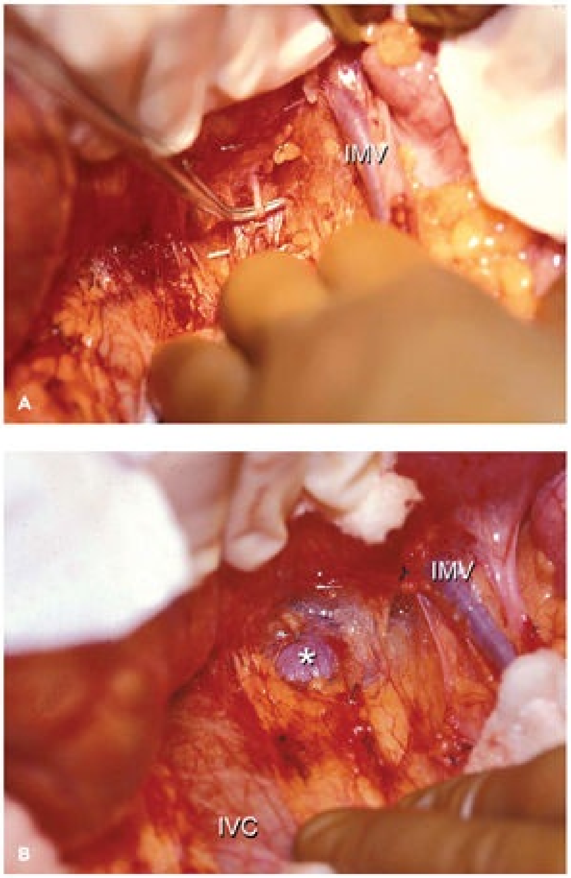

FIGURE 61.10 Retroperitoneal exposure. **A:** Large lymphatics found on the undersurface of the pancreas are divided with surgical clips or silk ties. **B:** The left renal vein (*asterisk*) is a key landmark and represents the superior boundary of the dissection. *IMV*, inferior mesenteric vein; *IVC*, inferior vena cava.

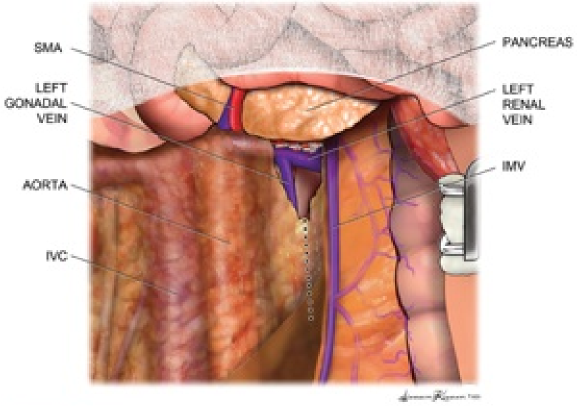

FIGURE 61.11 An important avascular plane between the left gonadal and IMV is developed. The mesentery of the colon lies anteriorly and Gerota fascia posteriorly. *IMV*, inferior mesenteric vein; *IVC*, inferior vena cava; *SMA*, superior mesenteric artery.

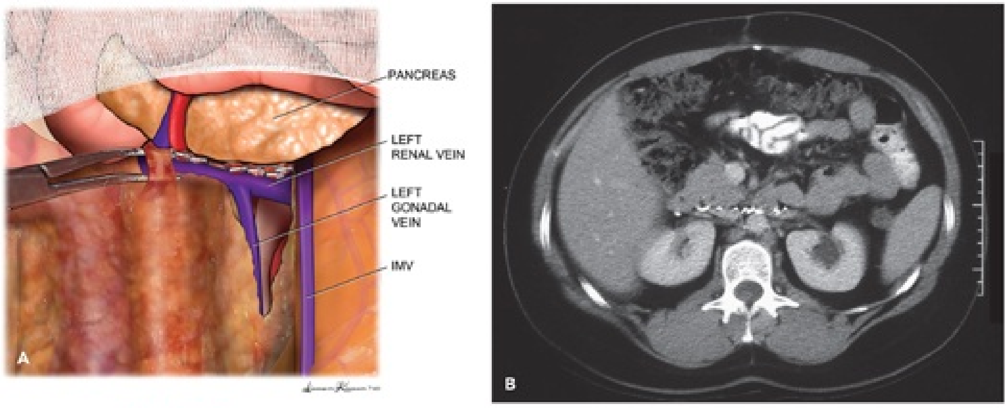

FIGURE 61.12 Clipping of lymphatics. **A:** Lymphatic channels on the undersurface are carefully controlled during exposure of the left renal vein. **B:** A postdissection CT scan shows a line of surgical clips with minimal lymphatic leakage. *IMV*, inferior mesenteric vein.

The small intestine, cecum, and right colon are reflected onto the chest wall to provide full exposure of the retroperitoneum (Fig. 61.13). The reflected intestine is wrapped with protective moist laparotomy pads. Retraction of the externalized viscera is maintained with the use of a Gallagher device with two self-retaining Deaver retractors (Fig. 61.14). Each retractor blade is padded with three additional moist laparotomy pads. Care is taken to ensure that there is minimal traction on the externalized structures, particularly of the superior mesenteric artery (SMA), duodenum, and pancreas. Periodic inspection of the bowel and assessment of SMA pulse should be performed to evaluate adequacy of blood flow to these reflected structures. The Deaver retractors are taken off traction periodically and only used during periods of active dissection where their use is required.

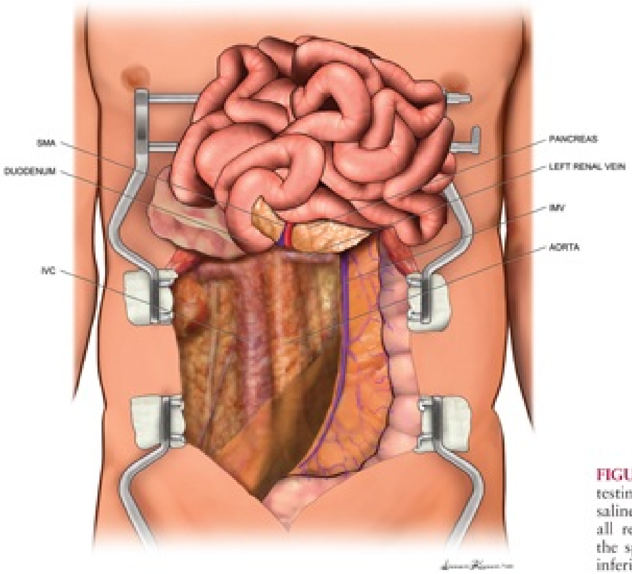

FIGURE 61.13 Retroperitoneal exposure. The small intestines are placed on the chest wall and protected with saline-soaked laparotomy pads. After careful inspection of all retractors, a split-and-roll technique is used to excise the specimen en bloc. *IMV*, inferior mesenteric vein; *IVC*, inferior vena cava; *SMA*, superior mesenteric artery.

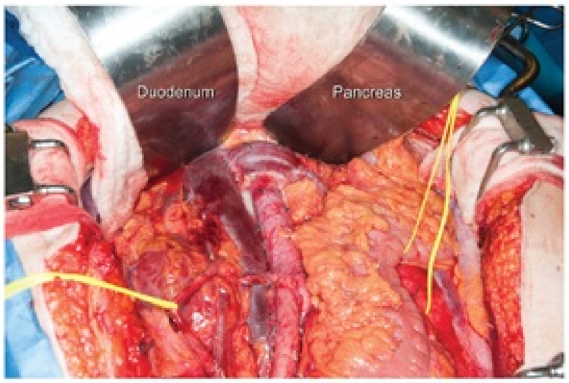

FIGURE 61.14 Gallagher retractor positioning. The Gallagher retractor is used to provide carefully controlled exposure during the superior dissection. The large Deaver retracting attachments each retract the duodenum and pancreas, and this retraction is released as the dissection moves to other areas.

The left white line of Toldt is incised, and the plane between the mesentery of the left colon and the left renal fascia is developed. The left colon is mobilized off the renal fascia and can be retracted both laterally and medially for exposure of the para-aortic region. If necessary, additional exposure of this area can be achieved by sacrificing the IMV or IMA. Collateral circulation from the marginal artery of the colon (Drummond) makes division of the IMA possible.

The ureters are identified near the common iliac vessels, encircled with vessel loops, and carefully mobilized proximally and distally. They are laterally retracted out of the dissection field (Fig. 61.15). These mark the lateral boundaries of the dissection. Feeding vessels and lymphatics to the periureteral tissue are carefully clipped and divided. The ipsilateral gonadal vein is dissected free at its origin, divided, and tucked away for subsequent resection. Prior to manipulation of the renal vessels, 12.5 g of mannitol may be administered intravenously. Papaverine should be available for direct application on the renal vessels should vasospasm occur.

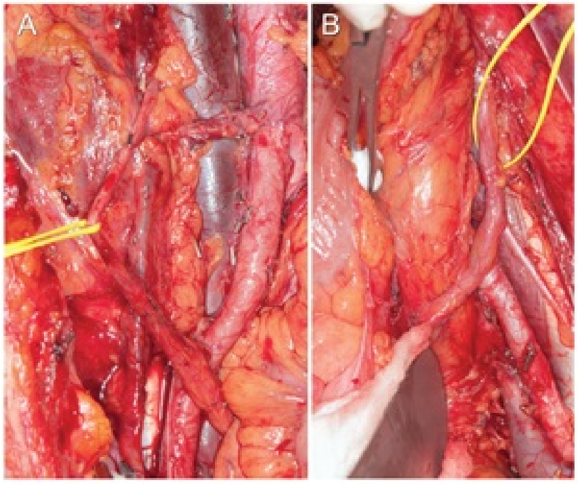

FIGURE 61.15 Lateral boundaries of the dissection. The left (**A**) and right (**B**) ureter are dissected free, encircled with vessel loops, and protected.

Lymphadenectomy

Adequate exposure is integral to the success and safety of this procedure, and the steps described earlier are undertaken to reveal the key structures of the retroperitoneum (Fig. 61.16). The lymph node dissection begins on the left renal vein, where the perivascular lymphatic tissue on the inferior border of the vessel is mobilized and the aortic surface exposed. Adrenal and lumbar branches are identified, ligated, and divided with 3-0 silk sutures. The dissection is carried toward the IVC. The first split-and-roll maneuver begins on the anterior surface of the IVC. The perivascular lymphatic tissue is split from the insertion of the left renal vein to the crossing of the right common iliac artery. This tissue is carefully freed from the IVC laterally and medially (Fig. 61.5A). The Penfield dissector is useful for atraumatically separating the lymph node packet away from the nerves and great vessels. Perforating vessels are commonly encountered, which are doubly clipped and divided. Lumbar veins are carefully identified, exposed, ligated, and divided between rows of surgical clips. Ligation of the lumbar veins prevents bleeding from inadvertent avulsion and increases the mobility of the IVC to enable complete removal of lymphatic tissue located posterior to the IVC and anterior to the anterior spinous ligament (ASL). Lumbar arteries that are identified are clipped with rows of multiple surgical clips. The arteries are not immediately divided but kept clipped in place temporarily to facilitate exposure. The right gonadal vein usually originates from the anterior surface of the IVC and should be doubly ligated with 3-0 silk ties and divided.

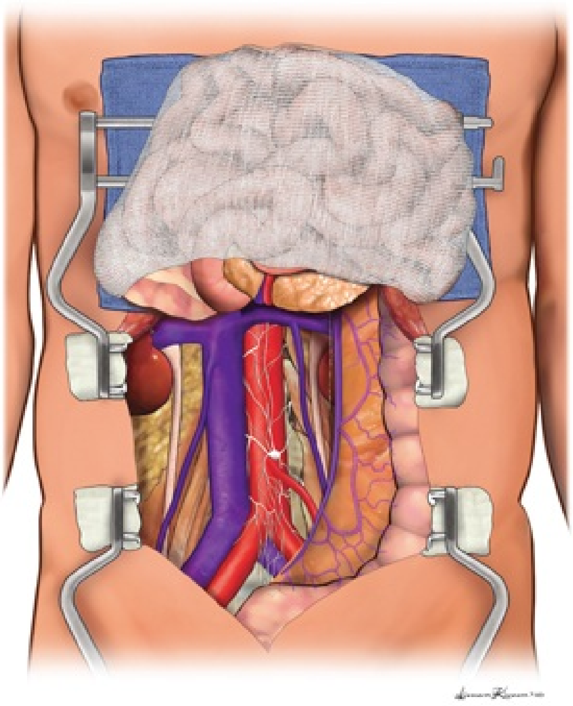

FIGURE 61.16 Retroperitoneal anatomy after exposure.

The nerves originating from the right sympathetic trunk emerge from the interaortocaval space on the medial border of the IVC are identified and marked with white vessel loops (Figs. 61.5 and 61.17). They are carefully dissected free of the precaval and interaortocaval lymph node packets and carefully retracted so that an anterior split can be made on the aorta without dividing the nerves (see Fig. 61.5). The Penfield dissector performs well in dissecting apart these structures. This split is extended from the left renal vein to the left common iliac artery. The gonadal arteries are ligated and divided at their origin. Care must be taken to preserve the hypogastric neural plexus. Lumbar arteries are ligated at their origin at the aorta. The crus of the diaphragm are visualized, and the large lymphatic channels traversing this region into the mediastinum are clipped (Fig. 61.18). Care is taken to ensure there is no leakage of lymph from the cisterna chyli, which is situated near the crus of the diaphragm and may appear as a saccular dilatation of the main lymphatic trunk. Once the IVC and aorta have been fully mobilized from their posterior attachments, the posterior lymphatic tissue is resected from the psoas fascia and ASL posteriorly, which should be completely visible at the conclusion of lymphadenectomy (Fig. 61.19).

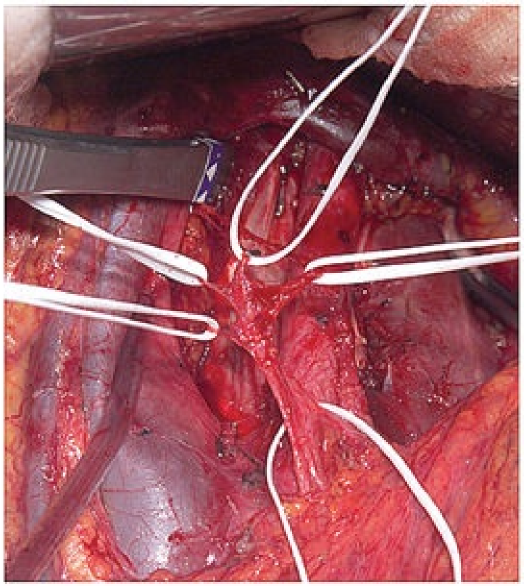

FIGURE 61.17 Postganglionic retroperitoneal nerves are prospectively identified, marked with vessel loops, and protected during lymphadenectomy.

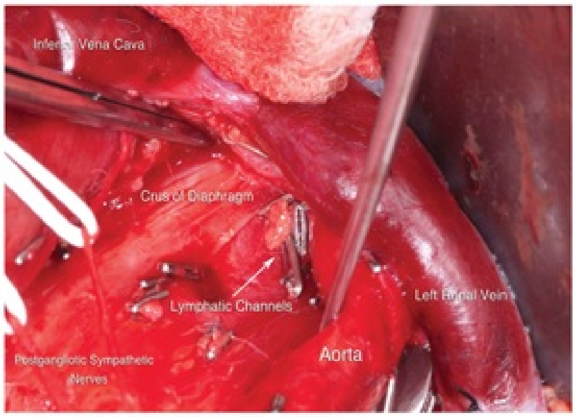

FIGURE 61.18 Large lymphatic channels are carefully ligated where they travel between the diaphragmatic crura into the mediastinum.

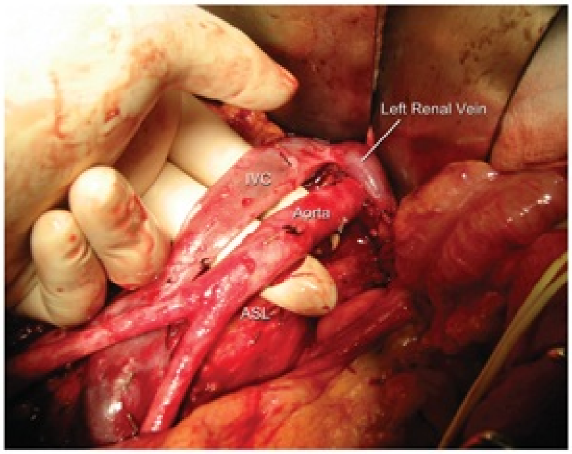

FIGURE 61.19 The posterior boundary of dissection is the psoas fascia bilaterally and the anterior spinous ligament (*ASL*). With careful control of the lumbar branches, the great vessels are fully mobilized. *IVC*, inferior vena cava.

The ipsilateral gonadal vessels are traced down to level of the internal inguinal ring, with all associated lymphatic vessels clipped and divided. The vas deferens is ligated and divided between 0 silk ties. The spermatic cord and surrounding fibroadipose tissues are then dissected free and excised in its entirety to avoid late paracolic recurrences (31).

Careful inspection of the dissection bed is performed and meticulous hemostasis and lymphostasis is performed. Lymphatic leaks are particularly problematic behind the right renal artery, the retrocrural space, and in the vicinity of the origin of the IMA. The skeletonized IVC and aorta are visualized, as is the underlying ASL. The sympathetic chains, the postganglionic sympathetic nerve fibers, and hypogastric plexus are inspected. The ureters, renal vessels, kidneys, pancreas, duodenum, and SMA are inspected for signs of injury (Fig. 61.20). Irrigation with a solution of sterile saline and hydrogen peroxide can be used to assist with hemostasis.

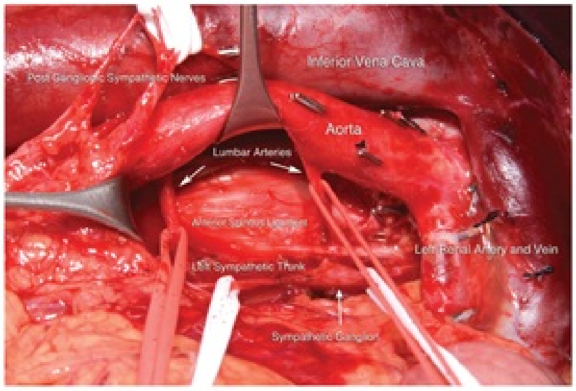
Inferior Vena Cava
Post Ganglionic Sympathetic Nerves
Aorta
Lumbar Arteries
Anterior Spinous Ligament
Left Renal Artery and Vein
Left Sympathetic Trunk
Sympathetic Ganglion

FIGURE 61.20 Full-template bilateral nerve-sparing RPLND. The ASL is exposed following removal of the lymph nodes. Note the relationship between the lumbar arteries and the left sympathetic trunk, as the vessels enter the lumbar foramina medial to the sympathetic trunk.

The intestine is brought down and the posterior peritoneum is reapproximated with running 2-0 chromic suture. The bowel is carefully placed in orthotopic position. The colon is replaced and the omentum is draped over the exposed peritoneal contents. No drains are used. The fascia is closed with 1-0 polydioxanone suture (PDS), with a series of interrupted figure-of-eight sutures along the entire length of divided fascia. Additional 1-0 PDS interrupted sutures are used intermittently for reinforcement of the closure. For patients with only a thin subcutaneous layer, the knots are buried. The subcutaneous tissue is copiously irrigated. A 3-0 Vicryl is used to close the subcutaneous layer, and skin staples are used to close the skin. A sterile dressing is applied.

Postoperative Care

Patients are extubated at the end of the procedure, and postoperative nasogastric tube drainage is not required except where extensive duodenal involvement or manipulation occurred. Fluid input and output are closely monitored with strict nursing documentation, daily weights, and physical examination. Patients who have undergone chemotherapy with bleomycin are particularly susceptible to potentially life-threatening pulmonary complications and require judicious fluid management. Postoperative tachycardia is common due to sympathetic nervous discharge and not an indication for aggressive fluid administration. As bowel function returns, the diet can be advanced, and length of stay typically ranges from 5 to 7 days.

Complications

RPLND is associated with several known major complications, which are closely associated with the burden of disease, the complexity of the procedure, and prior exposure to chemotherapy.

Vascular complications are rare in primary RPLND, but prior chemotherapy and/or bulky lymphadenopathy may significantly increase the risk of vascular injury (32). The SMA must be identified early and protected at all times. Injury to major, segmental, or accessory renal vessels can lead to loss of renal function, especially with large para-aortic masses involving the left renal hilum. In these difficult cases, adjunctive nephrectomy may be required (33). Bulky retroperitoneal lymphadenopathy can involve the IVC, and in the majority of cases where IVC invasion was present (67%), invasive teratoma or carcinoma was observed on pathology (34). This requires segmental resection of the IVC to ensure a complete resection, which involves careful sparing of key collaterals, and possible placement of an interposition graft (35).

Lymphatic leakage is inevitable despite meticulous lymphostatic surgical technique. Small lymphatic collections are commonly visible in postoperative imaging and are usually asymptomatic, benign, and self-limited. Rim-enhancing fluid collections are concerning for retroperitoneal abscess formation, especially if accompanied by symptoms of fever, chills, or pain. These are treated with antibiotics and percutaneous drainage. Significant leaks can lead to chylous ascites, which presents as abdominal distention, weight gain, sensation of fullness, and dyspnea (36). Chylous ascites can usually be managed conservatively with diuretics and initiation of a low-fat diet. A diet containing protein and medium-chain triglycerides are transported into the portal circulation and reduces flow through intestinal lymphatics (37). Intermittent paracentesis may be required. Where diet modification is insufficient, total parenteral nutrition may be used to further decrease lymphatic flow while supporting nutritional deficits (38). In certain cases, adjunctive use of octreotide has been shown to further diminish the output of chyle (39). Significant ascites that is refractory to conservative management may require a peritoneovenous shunt (34).

Traction on the duodenum and pancreas can result in a pancreatitis that is transient, characterized by nausea, vomiting, and elevated serum amylase and lipase. Bowel rest, fluid, and nutritional support may be used to conservatively manage this complication.

Bleomycin can cause a hypersensitivity pneumonitis that leads to lung fibrosis. Symptoms of chest pain and dyspnea can occur in delayed fashion, months after initial exposure. This pulmonary toxicity is lethal in less than 1% of patients receiving three cycles of bleomycin, etoposide, and cisplatin and increases to 1% to 2% after four cycles (40,41). Acute respiratory distress following bleomycin exposure may be linked to high intraoperative oxygen tension and should be avoided (42). Most important is careful fluid management, which is essential both intraoperatively and in the postoperative period (43). Pulmonary physiotherapy and early ambulation are important adjuncts in the reduction of pulmonary complications. Patients with active pneumonitis require treatment with corticosteroids.

CONCLUSION

RPLND plays a critical role in the staging, prognostication, and treatment of testis cancer. Although early outcomes for modified template RPLND in the primary or postchemotherapy situations have appeared favorable, longer term follow-up with larger cohorts of patients are necessary to assess rates of recurrence. The standard of care for PC-RPLND remains full bilateral RPLND, which achieves optimal cancer control rates and when combined with techniques for the prospective identification and sparing of autonomic nerves achieves excellent rates of antegrade ejaculation.

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CHAPTER 62 TORSION OF THE TESTICLE

DIANA K. BOWEN AND ROBERT E. BRANNIGAN

Testicular torsion is a true urologic emergency, requiring a provider to arrive at a timely diagnosis with a fast transition to surgical intervention in order to prevent testicular injury or necrosis. It is a clinical problem in both pediatric and adult urology, with a recent population-based study giving a yearly incidence of 3.8 in 100,000 for males younger than 18 years old (1). This predicts that 1 in 1,500 males will undergo surgery for torsion by that age, compared to older estimates of 1 in 4,000 for men younger than 25 years old (2). Despite wide recognition of this condition, 30% to 41% all cases will have a nonviable testis at the time of surgery and undergo orchiectomy (1,3,4). Ramifications of delayed treatment include atrophy, possible testicular loss, decreased endocrine function, and reduced sperm count and future fertility. If torsion is suspected, emergent scrotal exploration should be undertaken given that even partial necrosis has been seen to occur as early as 4 hours (5,6). The injury to the testis occurs from ischemia as well as reperfusion from reactive oxygen species (7).

There is a bimodal incidence of torsion with peaks at 1 month of age and a second at 12 years, thought to reflect the clinical distinction between extravaginal torsion in the perinatal period and intravaginal torsion in older children. In this way, the anatomy of a testicular torsion is correlated with the expected age of the patient—the point of difference is whether the torsion occurs above or below the reflection of the tunica vaginalis (Fig. 62.1). Intravaginal torsion results from a twist in the spermatic cord within and not involving the tunica vaginalis. Also known as a “bell clapper deformity,”, it is hypothesized to be due to an abnormally high insertion of the tunical attachments to the testis and epididymis so that there is incomplete attachment (Fig. 62.2). Intravaginal torsion is seen in the older age group primarily, although can be seen rarely in the perinatal period. Surprisingly, autopsy studies report the incidence of a bell clapper deformity to be as high as 13% in normal subjects, thus unlikely to account solely for the cause of torsion (8). Individuals with undescended testes are also presumed to be at a higher risk although this is from only a handful of accounts and has not changed the current recommendations that infants undergo orchidopexy at the age of 6 to 12 months. At this time, no other predisposing factors can be definitively linked with testicular torsion.

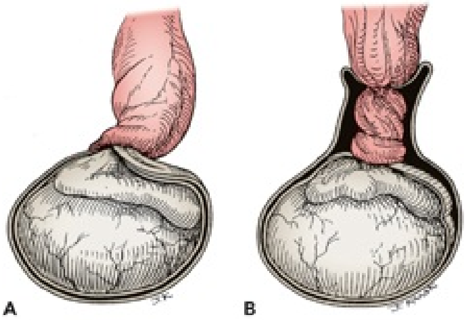

FIGURE 62.1 **A:** Extravaginal torsion. The tunica vaginalis is involved with the twist of the spermatic cord. **B:** Intravaginal torsion involves the spermatic cord below the reflection of the tunica vaginalis onto the spermatic cord. (Adapted with permission from Marshall, Fray F. *Operative Urology*. Philadelphia: WB Saunders, 1991:537. Copyright 1991 W.B. Saunders Co./Elsevier.)

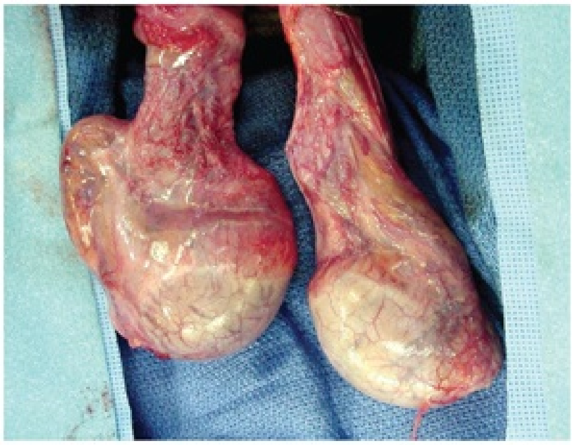

FIGURE 62.2 The patient's right testicle demonstrates a "bell clapper" deformity with anomalous attachment of the spermatic cord and testicle. The patient's left spermatic cord and testicle does not exhibit the bell clapper deformity. (Courtesy of Elizabeth B. Yerkes, MD.)

Extravaginal torsion, however, is a twist of the testis, cord, *and* tunica vaginalis due to deficient attachment of the gubernaculum to the dartos, and thus, it is much more likely to occur in the perinatal period. Possible predisposing factors include a large birth weight and difficult delivery, but these remain only postulations (9,10). Extravaginal torsion encompasses perinatal cases, of which an estimated 72% occur in utero and present as a "vanishing" nonpalpable testis at birth (11). The remaining important minority of cases present variably depending on the timing of the event and may be insidious. Suggestive findings at birth include an indurated, erythematous scrotum, a dark discoloration with or without edema, and/or a coexisting hydrocele. Often, the infant will be asymptomatic.

DIAGNOSIS

Clinical Presentation

The presenting signs and symptoms vary significantly by the type of torsion and therefore often the age of the patient; however, a sudden onset of pain and/or an abnormal hemiscrotum with a high-riding testis should always be concerning for testicular torsion.

Intravaginal Torsion

The description of sudden-onset unilateral testicular pain is a classic history for intravaginal testicular torsion. Nausea and vomiting are often present as well. On physical exam, the hemiscrotum can be swollen and edematous, and there may be evidence of a high-riding testis or horizontal lie. Lack of a cremasteric reflex, defined in one study as less than 0.5 cm elevation, has been highly associated with torsion, with positive predictive values of 43% to 83% and negative predictive values of 96% to 98% (12). However, the presence of a reflex does not rule out torsion (13). There is no single feature predictive of torsion, but a combination of two or three of these should be considered highly predictive (12).

Intermittent torsion is often a difficult clinical problem, as there may be no evidence at the time of evaluation of torsion. Patients may have recurrent bouts of pain that resolve rapidly and can occur with any time pattern. Making diagnosis even more difficult is that often ultrasound does not show evidence of reduced blood flow and typical physical exam findings, such as the cremasteric reflex, may not be present, even during a bout of pain (14). Bilateral elective orchidopexy can be considered based on a high degree of clinical suspicion.

Torsion of Appendage

Torsion of a testicular appendage is often characterized by a gradual onset and few systemic symptoms. Although the four testicular appendages that have been identified—the appendix testis (hydatid of Morgagni), the appendix epididymis, the paradidymis, and the vas aberrans of Haller—are all susceptible to torsion, the most commonly involved is the appendix testis. In the pediatric age group, appendiceal torsion is nearly as common as testicular torsion and accounts for 20% to 40% of acute scrotum cases (15). Early in the course of torsion of the appendix testis, physical examination may reveal a tender mass located at the upper pole of the testicle, sometimes adherent to the overlying skin. The testicle will usually have a normal orientation and the cremasteric reflex intact (13). There may be a tender mass located superiorly on physical exam, but torsion of the testicle and appendage can become clinically indistinguishable with time. Imaging with Doppler ultrasound frequently shows a hyperechoic mass at the upper pole of a normal-appearing testicle. Therapy consists of bedrest, scrotal elevation, and nonsteroidal anti-inflammatory agents as needed. Symptoms should begin to resolve within 1 to 2 weeks as the infarcted appendage is gradually resorbed. If testicular torsion cannot be ruled out with certainty, urgent surgical exploration is needed.

Extravaginal Torsion

In prenatal torsion, the first newborn exam will usually reveal a firm scrotum that is indurated and either erythematous or with a darker hue than the contralateral side (Fig. 62.3). Often, this is an isolated finding and the infant will not be systemically symptomatic. This is in opposition to postnatal torsion, which is new in onset after birth, and more likely to be accompanied by irritability and crying. The decision to operate in the perinatal period is controversial depending on the timing of findings and age of the patient. There is a conceptual difference between prenatal and postnatal torsion stemming from the fact that prenatal torsion is rarely salvageable and thus exposes an infant often within the first month of life to the risks of general anesthesia and surgical complications. Kaye et al. (10) advocates that infants found to have a unilateral prenatal torsion be treated with orchiectomy and contralateral orchidopexy after 1 month of age, as the risk of complications is greatest before this time period. On the other hand, bilateral prenatal torsion (or any bilateral torsion for that matter), and unilateral postnatal torsions should be taken for immediate exploration and potential orchidopexy. The argument against delaying exploration in prenatal cases is both the possibility of salvage, albeit low, as well as the possible occurrence of bilateral synchronous or asynchronous testis torsion, which may not be as rare as previously thought (16).

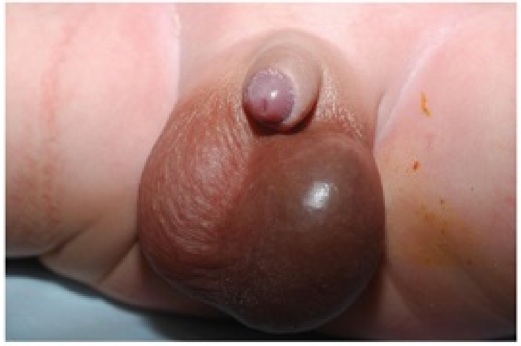

FIGURE 62.3 Typical appearance of postnatal testicular torsion, with left hemiscrotal discoloration and edema. (Courtesy of Dennis Liu, MD.)

Differential Diagnosis

The differential diagnosis for testicular torsion includes infection or inflammation (epididymo-orchitis), scrotal edema, hernia or hydrocele, torsion of the appendix testis, or trauma. It is especially important to be aware that torsion can occur in the setting of a trauma, potentially clouding the diagnosis. A more gradual onset of pain and urinary symptoms or a history of urinary tract infections are suggestive of epididymo-orchitis, which is commonly confused with torsion. Finally, torsion of a testicular appendage can present similar to testicular torsion, but the treatment for the former is purely conservative thus diagnosis is paramount. The pathognomic finding of an appendage torsion is the blue dot sign, which is the appearance of a small 1- to 3-mm palpable “dot” that has a bluish hue beneath the characteristically thin scrotal skin.

Diagnostic Modalities

Laboratory Testing

Basic laboratory testing includes a urinalysis to investigate for infection or hematuria. If an infection is considered, a urine culture, complete blood count (CBC), and serum chemistry may be indicated.

Ultrasound

In the mid-1990s, color Doppler ultrasound (CDUS) was introduced as an important tool in the diagnostic workup of torsion, and its use has steadily increased. Lack of intratesticular blood flow is the characteristic finding (Fig. 62.4). However, reports of an unacceptably high rate of false-negative exams remain, with an overall sensitivity ranging from 69% to 95% (17–21). This is likely due to the period of time before arterial blood flow ceases due to venous congestion and worsening edema. Some studies have suggested certain findings can increase the sensitivity for torsion such as noting a reversal of diastolic flow in the Doppler waveform or heterogeneous echotexture that may be predictive of eventual testicular loss (10,22). In addition, with high-resolution ultrasound (HRUS) that uses a higher frequency (10 to 20 mHz), visualization of the spermatic cord has been suggested as an adjunct. Kalfa (19) suggested the appearance of a cord twist on HRUS that looked like a whirlpool or “snail-shaped” mass was suggestive of torsion, although this is not 100% and more robust studies are needed to corroborate this finding (Fig. 62.5). Consideration should thus be given to perform the scrotal US exam up to the level of the internal ring for a more thorough evaluation of not just the testis but also the spermatic cord.

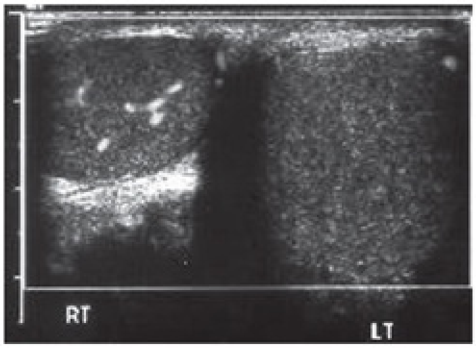

FIGURE 62.4 Doppler ultrasound of the scrotum showing a left testis with no blood flow adjacent to a normal-appearing right testis with blood flow. (Courtesy of Dennis Liu, MD.)

Time delay before the operating room is an important consideration with the use of ultrasound. One study found a 2.6 times greater length of time until the patient was taken to the operating room and questioned whether scrotal ultrasound should be routinely performed. In a prospective study of 236 patients with suspected testicular torsion (23) spanning 17 years, the authors noted a less than 15-minute estimated additional time for obtaining an ultrasound. All patients underwent surgical exploration, and the authors found a 100% sensitivity and 75.2% specificity, indicating that their high volume and tertiary care expertise were likely important factors in delivering this expedited care. More specifically, at this center, a senior urologist who was experienced in ultrasound performed the study during the initial triage in concert with ongoing preparations for surgery (23). This is an interesting paradigm, especially given the recent increase in urologists obtaining scrotal ultrasonography certification. However, until more prospective trials prove that the use of ultrasound does not significantly delay surgical exploration, urologists should not routinely depend on scrotal ultrasonography in determining whether or not to emergently operate.

Nuclear scintigraphy has been used historically in the evaluation of torsion, with less common use at this time. It is still employed, albeit rarely, as a diagnostic modality at some centers, where it is primarily used in children and adolescents as an adjunct in cases with equivocal results on scrotal ultrasonography (10). Drawbacks of nuclear scintigraphy include excessive length of time to perform the examination, radiation exposure with this test, and the low degree of sensitivity for testicular torsion. Magnetic resonance imaging (MRI) is not practical as it requires availability of the scanner and a lengthy time for the exam.

The drawbacks of ultrasound (time, operator dependency, false negatives) have led some to investigate other modalities that may be used clinically by first-line providers to expedite care. These techniques ideally would require less training than ultrasound and be readily available, such as near-infrared spectroscopy (NIRS), akin to pulse oximetry that measures oxygenation within seconds. NIRS uses infrared light to obtain continuous, noninvasive transcutaneous monitoring of deep tissue oxygen saturation in the testis (24). It promises a quantitative measurement of oxygen saturation versus a qualitative evaluation on Doppler ultrasound. An animal study showed that torsion was the most likely diagnosis with an oxygen saturation difference of 12% between the affected and contralateral testicle and that cases of torsion exhibited a rapid and sustained deterioration (25). From this, a pilot feasibility study was performed that identified all 16 surgically confirmed cases of an acute testicular torsion when the affected testis oxygen saturation was greater than 11.5 units lower than the contralateral testis (26). This is a promising area of investigation that may aid in a more rapid diagnosis and treatment plan than ultrasound currently allows for in equivocal clinical cases of suspected torsion.

INDICATIONS FOR SURGERY

At this time, there is no role for medical treatment or described medical adjuncts such as pentoxifylline and nitrous oxide in the treatment of torsion. Other agents thought to prevent testicular injury from reperfusion injury after torsion, including antioxidants such as N-acetylcysteine and *Rhodiola rosea*, have been studied in animal models but are investigational at this stage. Importantly, all of these adjuncts have been studied in combination with surgical intervention (27,28).

If there is a strong suspicion for testicular torsion based solely on history and physical exam in a child, adolescent, or adult, the patient should be taken immediately to the operating room for scrotal exploration. Manual detorsion is often attempted prior to operating, and the technique is described classically as "opening a book" based on the assumption that both testes twist medially or "inward" (the right clockwise and the left counterclockwise). However, a 2003 retrospective review of 186 torsions showed that lateral twisting occurred in approximately one-third of cases and moreover that resolution of symptoms after manual detorsion did not correlate with the presence or absence of persistent torsion upon surgical exploration (6). Thus, manual detorsion and any resulting relief should not delay nor negate an expeditious trip to the operating room.

The timing of operative intervention in extravaginal torsion is more controversial. The likelihood of testicular salvage and contralateral torsion in the time it takes to go to the operating room must be weighed against the risks of neonatal anesthesia, especially if not to be performed at a center with a specialized pediatric anesthesia team. Arguments for elective exploration include the fact that most cases do occur prenatally, that in most cases the affected testicle is *not* salvageable (<5% are salvageable), and that asynchronous torsion is very rare. However, proponents of a more aggressive approach who advocate for urgent or emergent surgery point to several recent studies that indicate asynchronous torsion may occur more frequently. These authors assert that the clinical signs of torsion may be subtle, delayed, and easily overlooked by even the most observant parents (9,16). In summary, any bilateral neonatal torsion or postnatal torsion (new evidence of torsion after a normal birth exam) are indications for emergent exploration; however, the timing of a prenatal torsion (i.e., one found at birth) is debatable.

Preoperatively, the patient and/or family should be counseled on the risks and benefits of the surgery, including options of contralateral fixation and/or testicular prosthesis placement should orchiectomy be necessary. Any prior pertinent surgeries such as hernia repair should be discussed. Perioperative antibiotics for skin prophylaxis are appropriate.

SURGICAL TECHNIQUE

The surgical technique is detailed in Figure 62.6. The patient is positioned on the operating table supine and the scrotum cleaned in the usual sterile fashion with an antiseptic solution such as Betadine or chlorhexidine gluconate. In older children, adolescents, and adults, a midline scrotal incision following the median raphe or a transverse incision in the correct hemiscrotum following the natural rugae of the scrotum are both appropriate. Electrocautery is used to dissect through the dartos layers maintaining good hemostasis and the tunica vaginalis is then identified. The testis and cord are delivered from the scrotum and a longitudinal incision is made in the tunica vaginalis to expose the testis and spermatic cord. The spermatic cord is inspected, and the presence of twists, the direction (medial or lateral) of twists, the number of twists, and the color of the testis—often black or dark purple if ischemic—are all noted (Fig. 62.7). Inspection and palpation for any masses or other suspicious findings should be performed. The testis is detorsed; wrapped in a warm, moist gauze; and set aside; attention is then turned to the contralateral scrotum and orchidopexy on that side to allow time for revascularization and reassessment of the torsed testicle for viability after this.

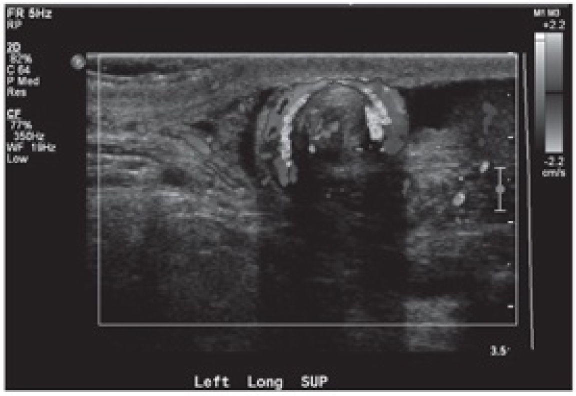

FIGURE 62.5 Doppler ultrasound image demonstrating the spermatic cord "whirlpool sign" superior to the testicle. This sign is sometimes seen in the setting of testicular torsion. (Courtesy of Robert E. Brannigan, MD.)

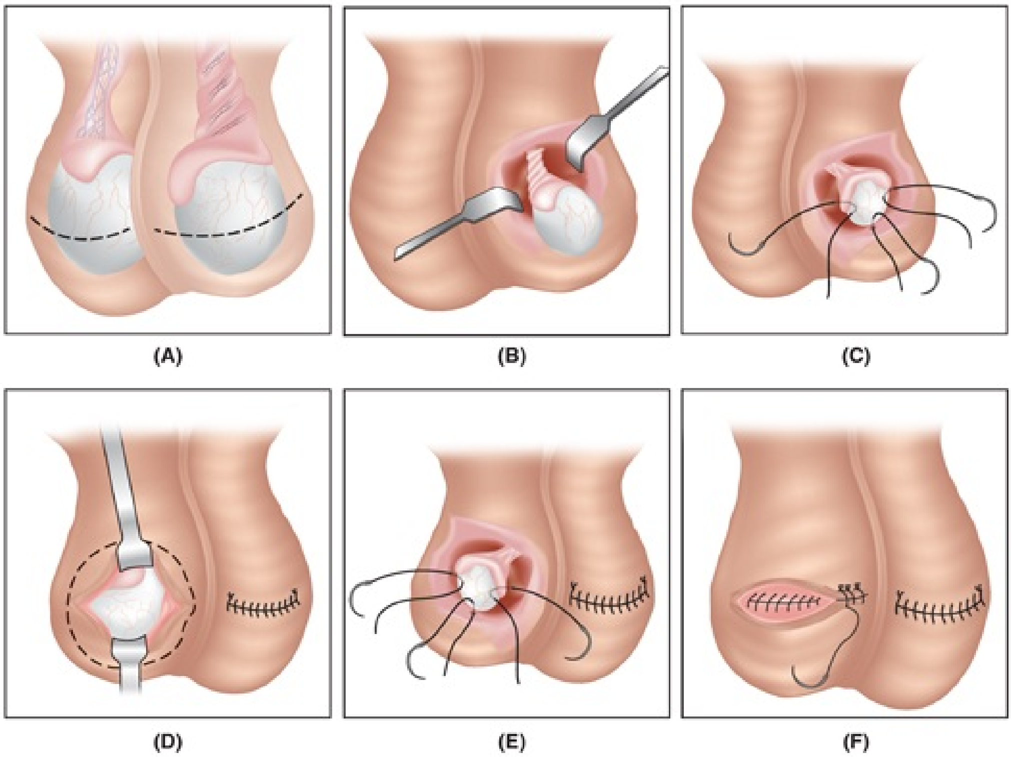

FIGURE 62.6 Steb-by-step scrotal exploration and orchidopexy for testicular torsion. A: Incision. B: Exposed testicle with twist in cord. C: *Arrow* showing untwisting. D: Three-point fixation with needles. E: Sutures tied down—with contralateral incision. F: Closed incision (dartos).

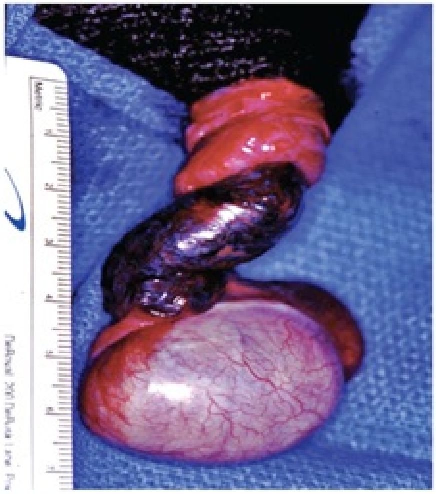

FIGURE 62.7 Intraoperative photograph demonstrating intravaginal testicular torsion, with discolored and edematous spermatic cord tissue evident distal to the twist. (Courtesy of Dennis Liu, MD.)

An important point of difference in the initial approach for infants is that an inguinal incision has been historically favored over a scrotal incision, as a hernia or rarely a tumor can be encountered and may be better handled with an inguinal incision. Despite this recommendation, surveys have found that 67% to 75% of urologists will actually perform a scrotal incision in perinatal torsion. This is postulated to be due to the increasing use of ultrasound to preoperatively rule out tumors and the ease of this surgical approach (11,29).

In cases of intravaginal torsion, bell clapper deformities usually exist bilaterally, thus it is advisable to routinely fixate the contralateral side. The same especially holds true for perinatal torsion with lower salvage rates, as often the goal of surgical exploration is to protect the normal contralateral side from an asynchronous torsion. The contralateral testis is delivered either through the same midline scrotal incision or a mirroring transverse incision in the contralateral hemiscrotum or inguinal region for infants (as previously discussed). The tunica vaginalis is opened longitudinally, everted posteriorly, and the edges then approximated. The tunica albuginea is then sutured to the dartos with either two or three separate interrupted sutures for stable fixation, thus minimizing the risk of future torsion. Eversion of the tunica vaginalis is an important step that helps eliminate the possibility of a future intravaginal torsion. Interestingly, several studies have shown that creation of a subdartos pouch is the most effective method to prevent retorsion, and this approach should be considered in the event of suture fixation failure with retorsion (30,31). There is debate about the best type of suture to use to secure the testis to the dartos tissue, namely absorbable versus nonabsorbable suture. Although in published series, authors have postulated a higher rate of retorsion with the use of absorbable sutures, retorsion has been shown to occur with both nonabsorbable and absorbable sutures (31,32). At this time, one is not recommended over the other. After inspecting carefully for hemostasis, the dartos is closed with a running 3-0 chromic suture in a locking fashion for hemostasis. We close the scrotal skin with a 4-0 Monocryl running horizontal mattress suture (see Fig. 62.6).

Next, the affected testis is readdressed and the decision to salvage the testis is made based on the perceived improvement in its color after revascularization. A fasciotomy can additionally be made in the tunica albuginea to decompress the testis and help assess blood flow. Every effort should be made to salvage the testis if even only mild improvement is seen after reperfusion, given the potential impact on future fertility and endocrine function. If the testis is deemed viable, the fasciotomy is then closed primarily with 4-0 chromic suture. Prior to this, a testicular biopsy may be taken and sent to pathology to assess for necrosis in a testis that is borderline, but this typically does not affect intraoperative decision making. The testis is placed back in the scrotum with attention paid to its correct alignment. As described with the contralateral side, a two- or three-point fixation is performed and the dartos and scrotal skin closed.

Interestingly, the use of a tunica vaginalis flap has been recently advocated in the pediatric literature to loosely cover a tunica albuginea fasciotomy and thus minimize the risk of increased intratesticular pressures (i.e., testicular compartment syndrome) sometimes seen in the setting of torsion (33). This compartment syndrome is theorized to occur after prolonged ischemia time, as there is resulting increased blood flow after the cord is untwisted and edema builds within the relatively inelastic tunica albuginea. Follow-up studies of this technique are equivocal at this time and long-term results are needed.

If a testis appears necrotic and does not improve with detorsion or fasciotomy over a period of several minutes, then it is deemed nonviable and should be removed to avoid continued pain and risk of infection.

Placement of a testicular prosthesis at the time of orchiectomy in adolescents and adults has traditionally not been done presumably due to the risk of infection or lack of preoperative discussion; however, there is no robust data to support the former paradigm. In fact, a recent series involving 12 pubertal patients whom had concurrent prosthetic placement within the tunica vaginalis revealed no infectious complications or erosion at a mean follow-up of 4.8 months (34). The authors note that instead of placing the prosthesis in a subdartos pouch, they fixed it near the cord stump and then secured it with preplaced tunical sutures (34). This study, combined with established data for prosthetic placement after radical orchiectomy for cancer, indicate that there may be a role for concurrent prosthetic placement, and this should be discussed preoperatively. If a testicular prosthesis is to be placed, a saline-filled silicone prosthesis is appropriate.

Complications of Procedure

Complications of the orchidopexy procedure include wound infection, pain, and scrotal hematoma. Long-term complications include necrosis of the testicle and retorsion.

OUTCOMES

Outcomes after surgical intervention for testicular torsion are focused on hormonal function, fertility potential as reflected by semen parameters, and viability of the testis. The primary determinants of testicular viability are the degree to which the spermatic cord twists and the duration of torsion. The literature reports low salvage rates in newborns (as low as 5%); however, these accounts do not always distinguish between prenatal and postnatal torsion. Long-term assessment of fertility in patients with perinatal torsion is lacking. Outside of this group, Workman and Kogan (35) found that patients who underwent surgery within 6 hours of onset had testicular salvage rates of 83% to 97%. This figure dropped to 55% to 85% between 6 and 12 hours of onset, and after 24 hours, the salvage rate fell to less than 10%. However, testicular salvage does not necessarily imply normal testicular function. Based on animal models, Turner et al. (36) showed that torsion can permanently affect fertility, despite the prompt return of blood flow, due to subsequent oxidative stress and germ cell apoptosis within the testis occurring with neutrophil recruitment. There appears to be possible contralateral dysfunction from unknown mechanisms but theorized to be due to immunologic mechanisms, previous episodes of silent intermittent torsion, or reflex vasoconstriction of the contralateral testis (7).

Testicular torsion is known to have deleterious effects on many semen parameters including sperm count, motility, and morphology, and these changes are associated with the duration of torsion and the degree of eventual atrophy (8,37,38). Despite this, torsion appears to play a small role in overall fertility, as only less than 1% of all adult males with infertility will have torsion as the main diagnosis (7). Sperm antibodies occur in 0% to 11% of patients with torsion; however, Arap et al. (39) studied 24 patients after testicular torsion and showed no correlation with antisperm antibody levels and duration of ischemia or treatment. They also showed that patients maintained normal hormone levels, and they reported that although sperm quality was preserved in most patients, those treated by orchiectomy presented better morphology compared with the orchidopexy group (39).

CONCLUSIONS

Testicular torsion remains a surgical emergency. A high index of suspicion on history and physical exam are sufficient to explore the patient surgically.

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CHAPTER 63 SCROTAL TRAUMA AND RECONSTRUCTION

K. JEFF CARNEY AND GERALD H. JORDAN

The anatomy of the male genitalia is quite complex. In the scrotum, there are multiple fascial layers (Figs. 63.1 and 63.2). From the standpoint of trauma, however, most of the fascial layers are relatively unimportant. The Buck fascia is related to the deep penile structures and is important in the containment of periurethral processes or the occasional hematoma associated with injury to the corpora cavernosa and/or corpus spongiosum. In the scrotum, the analogous fascia to the Buck fascia—the external spermatic fascia—is usually uninvolved with scrotal trauma (see Fig. 63.2).

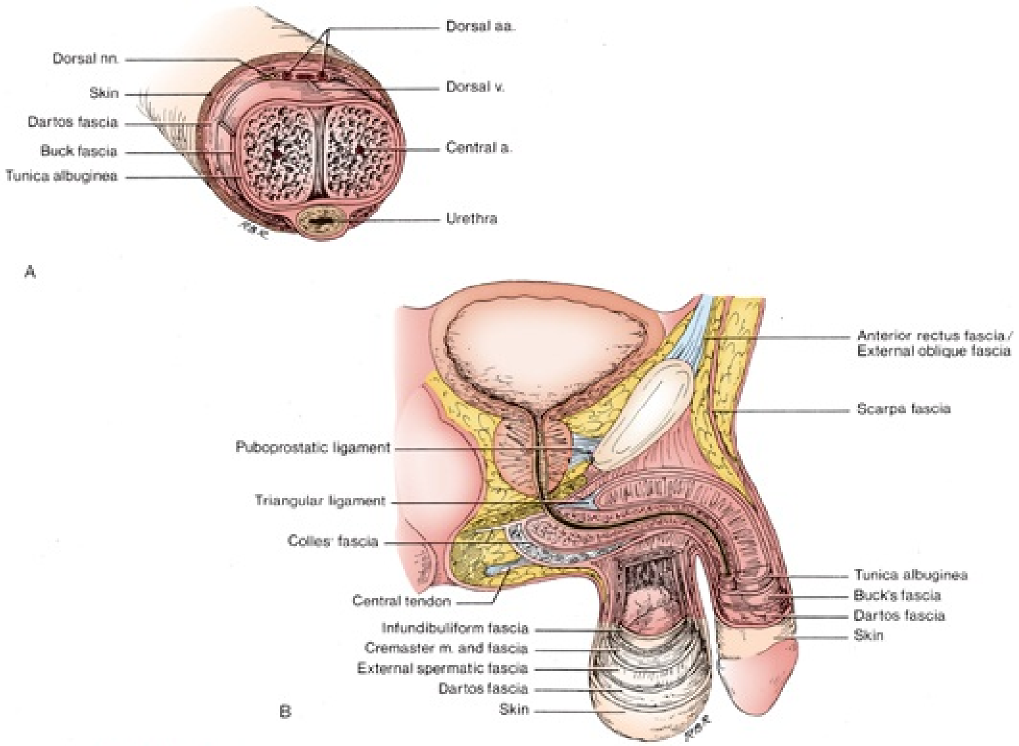

FIGURE 63.1 **A:** Cross section of the penis illustrating the fascial and structural components of the shaft of the penis. **B:** Sagittal section of the pelvis demonstrating the fascial layers and structural component.

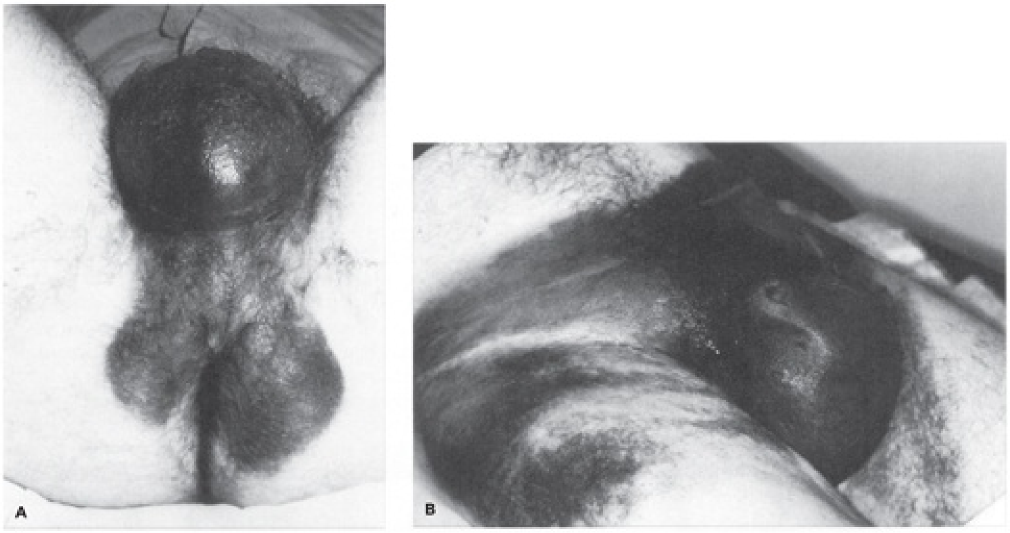

FIGURE 63.2 **A:** Perineal view of a trauma patient illustrating a hematoma contained by Colles fascia (classic butterfly hematoma). **B:** Same trauma patient illustrating the containment of the hematoma by the extended Colles layer, that is, the fascia lata of the thigh and extending onto the abdomen beneath the Scarpa fascia.

Culp (1) has classified injuries to the external male genitalia into five categories: nonpenetrating, penetrating, avulsions, burns, and radiation injuries (both direct and indirect). Nonpenetrating injuries result from either a crushing or sudden deforming force to the scrotum. These forces can cause severe damage to the internal structures without disrupting the skin. With any nonpenetrating trauma to the scrotum or perineum, one must suspect and rule-out injury to the corpus spongiosum and urethra.

DIAGNOSIS

The vast majority of penetrating injuries to the genitalia require surgical exploration, irrigation, a careful search for and removal of foreign-body material, anatomic repair, and drainage (Level of Evidence, LOE 4) (2). With traumatic injuries to the genitalia, the importance of a careful and thorough search for retained foreign body cannot be overstated. Torn and shredded fragments of clothing are commonly found in the wound and if missed can lead to sequelae of poor wound healing and recurrent abscess formation. In our current litigious environment, a missed foreign body following “surgical wound exploration” can be difficult to defend. Because these are often very dirty wounds, at our institute, we prefer the Pulsavac wound irrigation and debridement system to assist with a thorough wash out of the traumatized region.

Penetrating trauma to the genitalia may also involve the urethra. If there is any suspicion of urethral injury, a retrograde urethrogram or cystoscopy should be performed. Saline should be used for irrigation in these cases. Because of the position of the urethra beneath the scrotum and perineum, significant penetrating injuries to the scrotum can also often spare the urethra.

Avulsion injuries of the genital skin most frequently involve the loose hanging scrotal skin. Genital skin avulsion injuries are most commonly seen with either rapid deceleration injuries such as motorcycle accidents, when the rider is thrown over the handlebars and his clothing is caught on various stationary components of the motorcycle handlebars, or related to industrial equipment accidents, when the patient’s clothing becomes entangled in machinery and forcefully ripped away from the body. The loose scrotal tissues ensnare, and as the clothing is ripped off, so is the loose genital skin. These avulsion injuries vary from minimal injuries, which are essentially nothing more than jagged lacerations, to emasculating injuries, which take not only the skin but also the deep structures. Usually, with most scrotal injuries, the testicles are not involved or avulsed. Their mobility and the strength of the tunica albuginea afford the testicles protection. Most avulsion injuries fortunately occur along superficial avascular planes between the scrotal dartos and the external spermatic fascia, taking only the skin and the scrotal dartos fascia/tunica dartos and leaving the underlying Buck fascia of the penis and the external spermatic fascia and tunica vaginalis surrounding the testicle intact. Rarely, the testicle ensnares in the skin and is avulsed. In most cases of avulsion, bleeding is not a problem because the skin and fascia are avulsed in a relatively avascular plane between the fascial structures related to the deep structures and the superficial fascia.

Thermal burns to the genitalia are usually not isolated injuries but reflective of a more extensive area of body burn, as a rule of thumb, exceeding 40% of total body surface area. Genital burns are often seen following entrapment within a burning automobile or the spilling of hot cooking grease during transport. Chemical burns are in general only superficial and involve the skin. Thermal injuries can be deep, but often, even with extensive deep burns proximate to the genitalia, the multiple clothing layers (i.e., underwear and other clothing) afford some degree of protection of the genitalia. Electrical burns disseminate via the deep vascular and neurologic structures, and what may appear to be a minimal burn to the skin and scrotum may have associated significant deep injury, which can be devastating. Usually, however, the deepest burns associated with electrical contact occur at the site of the current inflow and the ground site. These sites are usually not the genitalia. However, it is not uncommon to have thermal burns in concert with electrical burns, as frequently the clothing is ignited by the electrical spark. Thus, with electrical burns, fortunately, if the genitalia are involved, it is usually a more superficial process.

For the most part, genital burns are managed like all other burns with a few exceptions. Debridement of the glans penis should be approached cautiously, and early aggressive, overzealous debridement of the glans penis should be avoided in favor of a wait-and-see approach to allow for demarcation. The abundant vascularity of the glans penis often allows for surprising delayed healing with excellent cosmetic results superior to those obtained from split-thickness skin grafts (STSGs). Urinary catheter insertion for fluid monitoring is almost always required in burn patients. In the case of severe genital burns, a suprapubic cystostomy can be placed in its typical location even if the suprapubic area is badly burned. If a urethral Foley catheter is used for fluid monitoring, it is important to continually reassess the necessity of the urethral Foley and to keep the penis secured to the abdomen in the anatomic position. Pressure from prolonged urethral catheterization of the edematous, compromised genital tissue, especially if the catheter is positioned in the customary dependent position and secured to the leg can result on pressure necrosis of the ventral urethra and urethral-cutaneous fistula (Fig. 63.3 Fig. 63.4 Fig. 63.5).

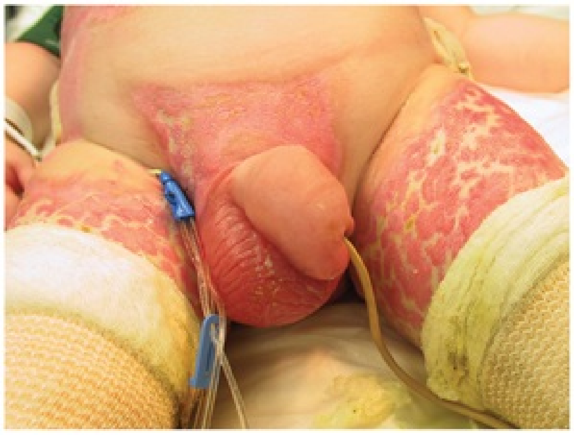

FIGURE 63.3 Second and third degree burns to the genitalia, with significant edema of the penile shaft skin. The utilization of a foley catheter with genital burns should continually be reassessed for removal after 48 to 72 hours or for conversion to suprapubic cystostomy to avoid urethral-cutaneous fistula.

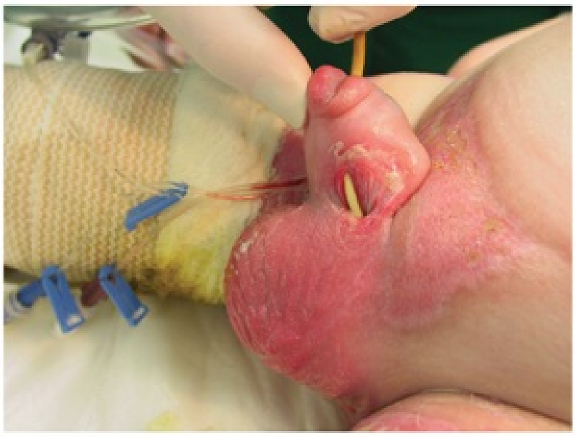

FIGURE 63.4 Urethral-cutaneos fistula as a result of second and third degree genital burns, to prevent this complication the use of urethral foley catheters should continually be reassessed after 48 to 72 hours with conversion to suprapubic cystotomy if longer periods of catheterization are necessary.

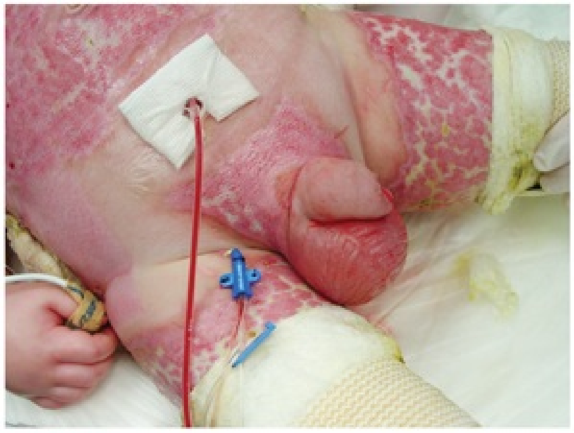

FIGURE 63.5 Suprapubic cystostostomy placed after urethral-cutaneous fistula due to second and third degree general burns.

Radiation injuries to the genitalia can occur either from direct exposure to the genitalia or from delayed effects of the radiation on the venous and lymphatic drainage. Complications of direct radiation injury to the genitalia are now uncommon, as radiation for penile lesions is rarely undertaken. The secondary effects of radiation, as seen in the scrotum, are usually manifested by chronic lymphedema, lymphangiectasia, and, in some cases, chronic recurring cellulitis.

To this list of traumas must be added the patient who has required significant debridement because of rapidly progressive, multiorganism fasciitis (Fournier gangrene). Fournier gangrene is often seen with processes of the anus or rectum, such as perianal abscess. Likewise, processes involving the urethra, such as urethral stricture with periurethral abscess, can accompany Fournier gangrene. Fournier gangrene is often associated with other comorbidities, such as diabetes mellitus and alcoholism. Given this multifactorial etiology, the associated comorbidities, and the rapid spread, these patients are best managed with a multispecialty approach involving urologists, general surgeons, and intensive/critical care specialist.

The necrotizing process can progress rapidly in a matter of only a few hours. Additionally, many of these patients present late; hence, aggressive and extensive surgical debridement (LOE 2) is required and can be lifesaving. At our institute, we take a more aggressive initial approach to debriding the necrotic tissue associated with necrotizing fasciitis than we do for burn patients. This aggressive debridement of necrotic tissue usually leaves a significant defect for the surgeon to reconstruct after the acute process is controlled (2). If the fasciitis is associated with pathophysiology of the urethra (i.e., stricture with perforation, extravasation, and abscess) and/or anus, then these situations must be managed and resolved before reconstruction (3). Urinary diversion in the form of a suprapubic cystostomy and fecal diversion via a colostomy are commonly required in management of the acute process. Recently, there have been descriptions of the use of unprocessed honey to augment or provide an alternative treatment to wide surgical excision. Honey apparently contains antimicrobial agents and enzymes to digest necrotic tissue as well as to promote epithelial growth (4).

Also, in recent years, we have seen several patients who have attempted to enhance the size and bulk of their genitalia with the injection of lipid-containing substances such as paraffin or petroleum jelly or inert substances such as silicone. In these cases, one is often confronted with a fulminant cellulitis that must be treated with broad-spectrum antibiotics. Later, one sees a sclerosing granulomatous process that can be troubling to the patients. In some cases, the skin must be excised along with the deeper involved structures, but it is not unusual to be able to excise the deep process and leave the skin that survives either on its random dermal blood supply or, in some cases, on the tunica dartos fasciocutaneous blood supply.

A contusion of the scrotum, that is, a scrotal hematoma, can be confused with a fracture of the testicle. The latter injury implies disruption of the tunica albuginea of the testicle. With a scrotal contusion, the hematoma usually is noted to be posterior and lateral to the testicle (Fig. 63.6), whereas with fracture of the testicle the parenchyma of the testis is not normal and is often associated with a hematocele if the visceral tunica vaginalis remains intact (Fig. 63.7). Physical examination remains the cornerstone in the diagnosis of blunt testicular trauma. However, the use of ultrasonography in the diagnosis of testicular trauma can be helpful in situations when the physical examination is difficult to perform or interpret. Ultrasonography is the most sensitive and specific imaging technique, with heterogeneity of the parenchyma of the testicle suggestive of testicular rupture (LOE 2) (2). In the presence of penetrating trauma to the genitalia, a cystoscopic evaluation or retrograde urethrogram is always indicated because of the close proximity to the urethra. In all cases of genital avulsion, other than a simple scrotal avulsion, a complete evaluation of the urethra must be done, along with a rectal examination and possibly flexible sigmoidoscopy.

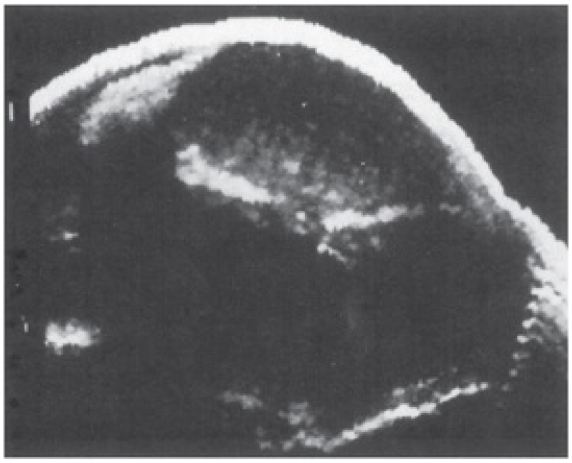

FIGURE 63.6 B-scan ultrasound demonstrating the classic distribution of a scrotal contusion (scrotal wall hematoma). Note the testis displaced anteriorly, with the hematoma contained in the multiple fascial layers of the scrotum.

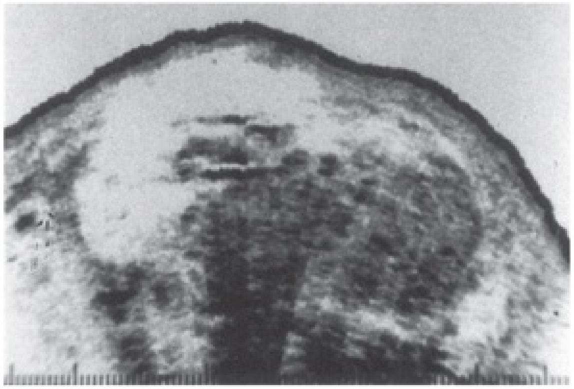

FIGURE 63.7 B-scan ultrasound of a patient with a fracture of the testicle. Note the disrupted parenchymal pattern of the testicle, the hematocele, and the demonstration of extruded seminiferous tubules within the hematocele.

INDICATIONS FOR SURGERY

Exploration of the scrotum is indicated if the patient has sustained either blunt or penetrating injury to the testicle (LOE 3) (2). Scrotal reconstruction is required following complex lacerations and avulsion injuries. If a patient has required excision for chronic cellulitis, lymphangiectasia, and lymphedema, STSG reconstruction of the scrotum is very effective and provides cosmetically very acceptable results. Meshing STSGs used for scrotal reconstruction allows for increased coverage, drainage of potential hematoma, and seroma accumulations, and the meshed graft mimics the natural rugae of the scrotum after it has healed. If the lymphedematous process is due to a local process, often the lateral scrotum and the posterior scrotum are spared from disease and uninvolved because the posterior scrotum is drained by the perirectal lymphatics. In these cases, lateral scrotal flap reconstruction is often very effectively employed.

If, however, the process causing the scrotal lymphedema is “systemic” (i.e., Charles disease, secondary to pelvic irradiation, etc.), then STSG reconstruction is always the best approach(5). Thicker grafts (0.016 to 0.02 inch) transport more collagen and elastin fibers and generally provide for superior elasticity and better cosmetic results. One word of caution, the lymphatics of the skin are carried in the reticular dermis (the deep layer of the dermis). So if a thick STSG is used to reconstruct the genitalia, in cases where the etiology of the scrotal lymphedema is systemic, then lymphedema can significantly recur in the graft. Therefore, for genital lymphedema secondary to systemic etiology, a thinner STSG (0.012 to 0.014 inch) is preferable. One must also be careful of the patient with scrotal lymphedema without “involvement of the penile skin”; following scrotal reconstruction, often the penile skin becomes edematous. Following burn injury to the genitalia, almost always graft reconstruction can be undertaken, and it offers extremely good functional and cosmetic results.

ALTERNATIVE THERAPY

Contusions of the scrotum are usually treated with bedrest, ice packs, analgesia, and scrotal elevation. Scrotal elevation can be accomplished very efficiently with a Bellevue-style (a taped suspensory dressing to elevate the scrotum) bridge or with scrotal support.

SURGICAL TECHNIQUE

Scrotal Hematomas and Blunt Testicular Injury

There is little to be accomplished in exploring the scrotal hematoma secondary to external blunt trauma, as the hematoma is usually disseminated throughout the highly elastic layers of the scrotum and does not form a drainable hematoma per se (1). On the other hand, if there is a testicular injury, exploration and repair of the testicle is indicated (Fig. 63.8). Exploration consists of exposure of the testicle. The space of the tunica vaginalis is opened; the hematocele is drained; the exposed, necrotic, seminiferous tubules are debrided; and the tunica albuginea is closed. The remaining viable testicular tissue should be salvaged for endocrine function and psychological impact (LOE 2) (2). A 3-0 or 4-0 polydioxanone or Monocryl suture is easy to handle, glides smoothly through the tissues without dragging and gathering the tissue, and performs well for repairing the tunica albuginea. The tunica albuginea is tough and fibrous, an RB-1 or SH needle works well for its closure. The parietal tunica vaginalis is left open and is reflected in typical bottleneck fashion as is done for a hydrocele repair. The scrotum is drained, and the skin closed with 3-0 polyglycolic acid (PGA) suture, chromic suture, or Monocryl. Alternatively, in cases of testicular fracture secondary to either blunt or penetrating injury, if the defect in the tunica albuginea is too large to allow for primary closure, one can cover the defect with a tunica vaginalis graft or island flap.

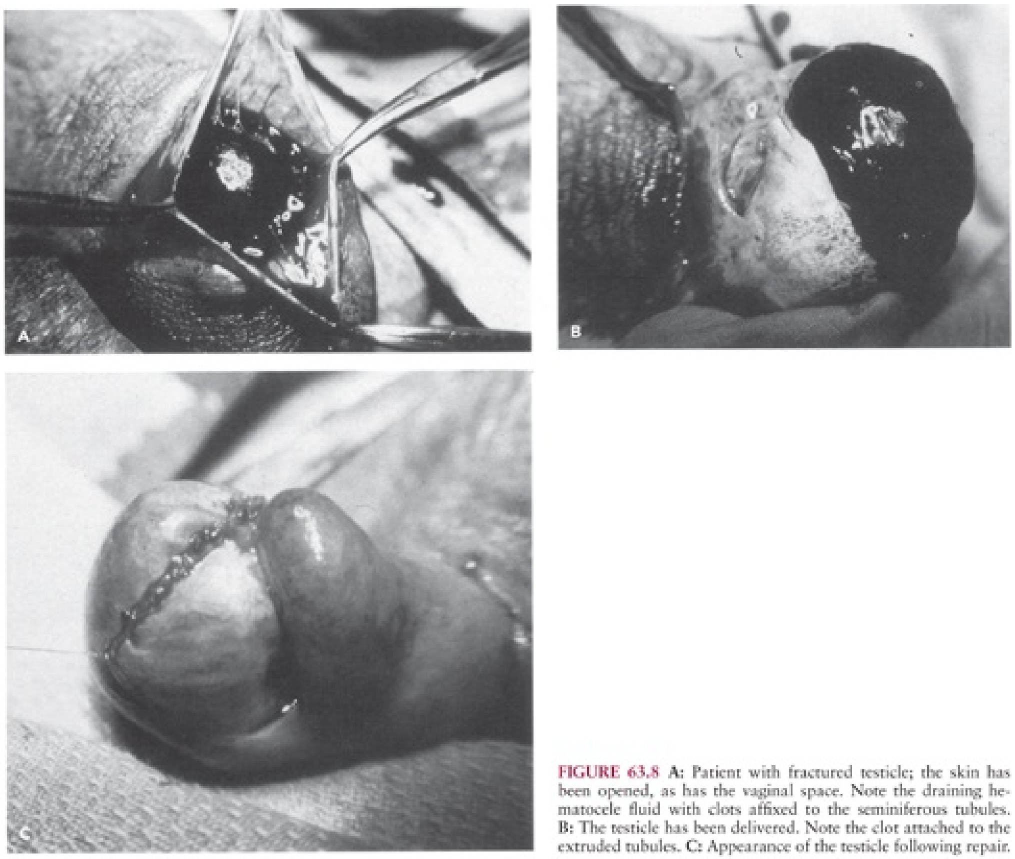

FIGURE 63.8 **A:** Patient with fractured testicle; the skin has been opened, as has the vaginal space. Note the draining hematocele fluid with clots affixed to the seminiferous tubules. **B:** The testicle has been delivered. Note the clot attached to the extruded tubules. **C:** Appearance of the testicle following repair.

Penetrating Injuries to the Genitalia

Penetrating injuries have been subclassified as either simple or complicated. By and large, complicated injuries imply urethral involvement, amputation, or near-total amputation, and with regard to the scrotum, they imply amputation of or injury to the testicle, with or without amputation of the overlying scrotal skin (Fig. 63.9). Simple lacerations are managed with thorough washout, primary closure, and drainage if indicated. In the case of amputation of the testicles, testicular microreplantation has been performed in high-volume academic centers, including vasovasostomy, along with reapproximation of the vasculature of the spermatic cord (Fig. 63.10). The testicle is placed, as quickly as possible, in a sterile bag in saline-soaked gauze, and that bag is placed in a second bag filled with saline slush for cold preservation. Unlike amputation of the penis, where successful replantation has been done as long as 18 to 24 hours from the injury, the testicle must be replanted by 6 to 8 hours due to the very high metabolic rate of the testicular tissue.

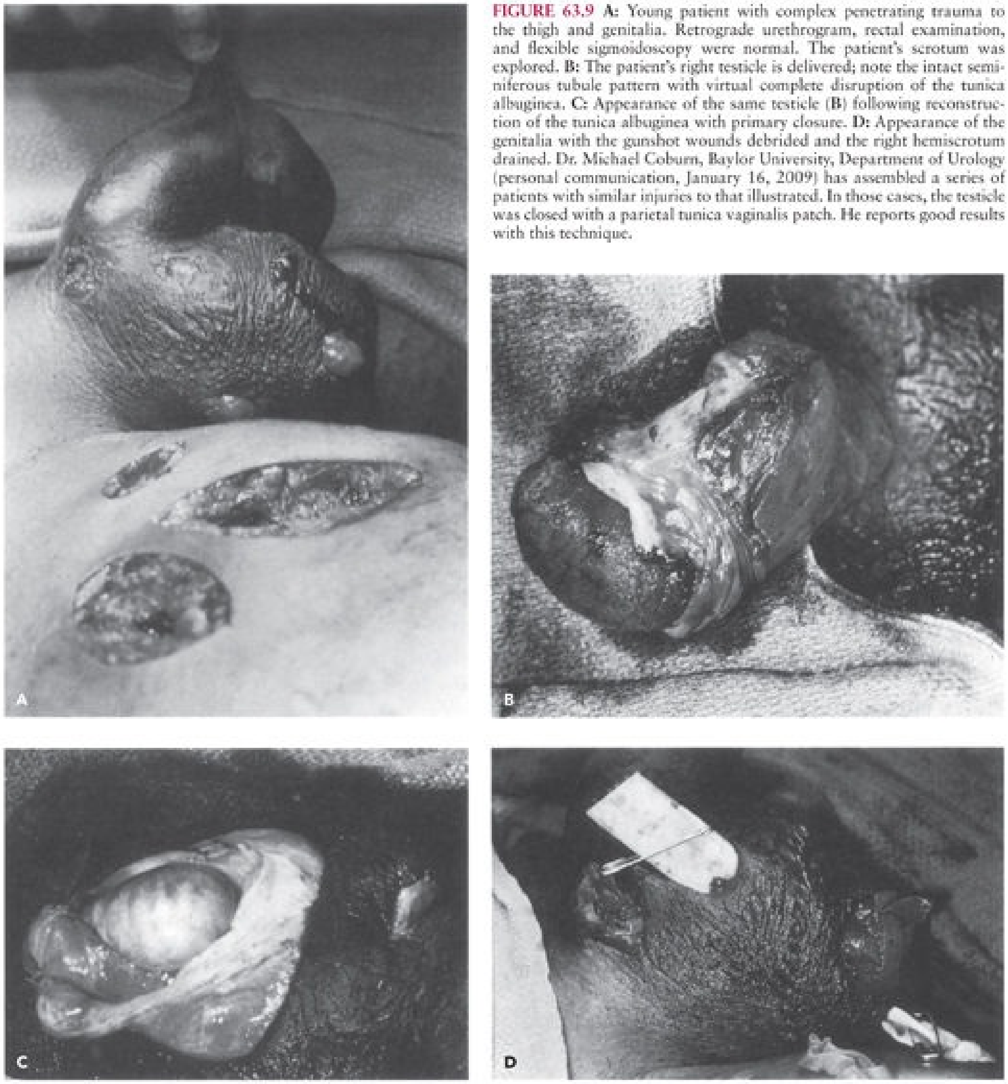

FIGURE 63.9 **A:** Young patient with complex penetrating trauma to the thigh and genitalia. Retrograde urethrogram, rectal examination, and flexible sigmoidoscopy were normal. The patient's scrotum was explored. **B:** The patient's right testicle is delivered; note the intact seminiferous tubule pattern with virtual complete disruption of the tunica albuginea. **C:** Appearance of the same testicle (**B**) following reconstruction of the tunica albuginea with primary closure. **D:** Appearance of the genitalia with the gunshot wounds debrided and the right hemiscrotum drained. Dr. Michael Coburn, Baylor University, Department of Urology (personal communication, January 16, 2009) has assembled a series of patients with similar injuries to that illustrated. In those cases, the testicle was closed with a parietal tunica vaginalis patch. He reports good results with this technique.

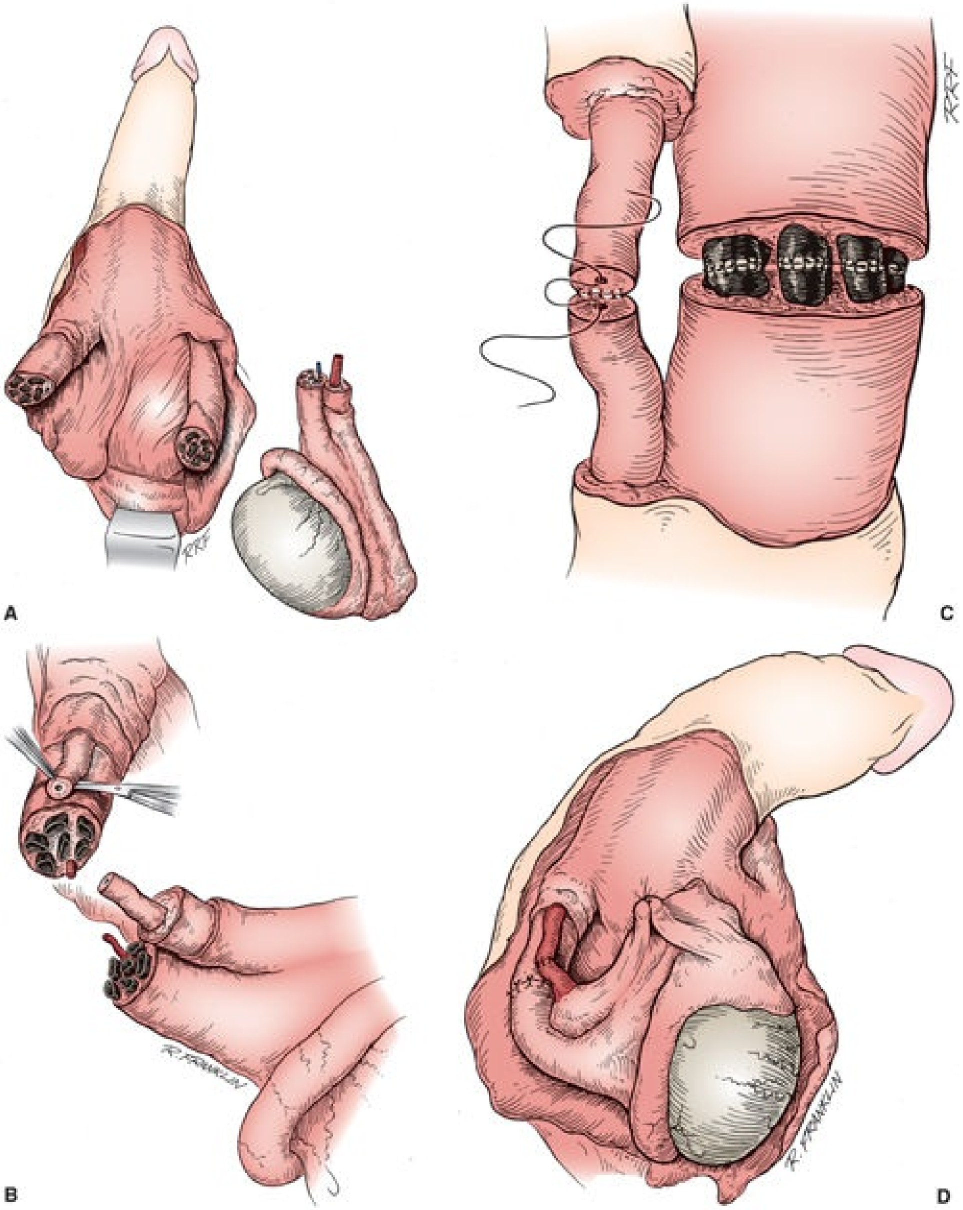

FIGURE 63.10 **A:** Appearance of a patient following bilateral testicular amputation and scrotal amputation. The patient presented with only his right testicle. The left testicle could not be found at the trauma scene. **B:** The right testicle is reanastomosed to the left (longer) spermatic cord. **C:** Note the appearance of the debrided spermatic cord and the debrided distal spermatic cord going to the testicle. Vasovasostomy was performed with a two-layer microscopic technique. Microscopic coaptation of the spermatic artery and multiple spermatic veins was performed. **D:** Appearance of the replanted testicle before closure of the scrotum.

In cases where the amputated testicle is traumatically avulsed and forcefully ripped away from the body, replantation is not an option. During the avulsion injury, the vasculature is stretched before giving way to the force, the anatomic structures are torn and ragged, and the endothelial damage can be significant and unpredictable.

Even with clean-cut amputations, there can be some difficulty in identifying the vessels in the spermatic cord, although they are somewhat compartmentalized. Identifying the artery proximally is not too difficult, and identification of the distal artery in the severed organ can be aided by examining the relationship of the compartments to the vas deferens. Coaptation of the artery and a number of veins is optimal using 9-0 or 10-0 Prolene, depending on the size of the respective vessels. Vasovasostomy can be done using 9-0 or 10-0 Prolene or nylon sutures, either with a classic microscopic two-layer technique or a single-layer “tricorner” technique, depending on the surgeon’s preference.

The replanted testicle should not be covered with a skin graft because an unsuccessful replantation will result in necrosis and infection, thereby leading to graft failure. The replanted testicle should either placed in a thigh pouch for possible later liberation or, if there is some remaining redundancy of the scrotum, covered primarily with reapproximation of the remaining scrotal tissues. Alternatively, we have left the replanted testicle out and dressed it with wet-to-dry saline gauze; this allows for easy visual inspection and Doppler examination in the crucial few days following the replantation. If left out, we secure the testicle to a nearby structure (i.e., inner thigh, scrotal wall, etc.) to prevent torsion.

Obviously, if the patient arrives without his amputated testicle, then hemostasis must be ensured. Usually, the vessels are in spasm, but they clearly can come out of spasm later. The wound should be thoroughly irrigated and, if contaminated, packed initially and later closed by secondary intention. If the wound is clean, then primary closure or primary grafting can be performed.

Avulsion Injuries

Small scrotal avulsions are managed as simple lacerations with either primary or delayed closure and drainage, as would be indicated for any laceration (LOE 3; Fig. 63.11) (2). The scrotum is very forgiving, so that in cases of primary closure, "loose" reapproximation can be performed to allow for better drainage without compromising cosmetic results. For larger injuries, many experts recommend a delayed approach, allowing time for complete demarcation (Fig. 63.12). The area of the avulsed scrotum should be managed with cold saline packs and observed over 12 to 24 hours. Clear demarcation will occur and allow the surgeon to debride only the tissue that is nonviable. Debridement with closure is then performed (LOE 3) (2). Although allowing time for demarcation is clearly sound surgical principle and works well in patients of Caucasian descent, in reality, our institute is an inner-city facility treating primarily minorities of African descent with dark skin pigmentation. Hence, nonviable skin edges remain difficult to discern even with delayed management. The loose, viscoelastic scrotal skin is forgiving, and usually, primary closure can be accomplished even with substantial skin loss up to 60%. Postoperatively, the testicles should be kept in the dependent position so as to serve as natural tissue expanders during the healing process, thereby resulting in excellent final cosmesis.

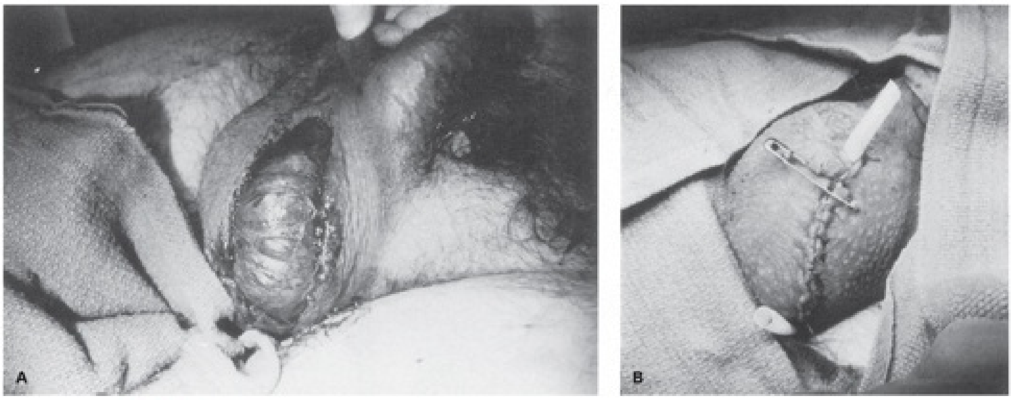

FIGURE 63.11 **A:** Appearance of a left scrotal avulsion injury. The patient was injured in a motorcycle accident in which his trousers were ripped off as he departed the motorcycle. **B:** Appearance after closure. Primary closure is performed with drainage.

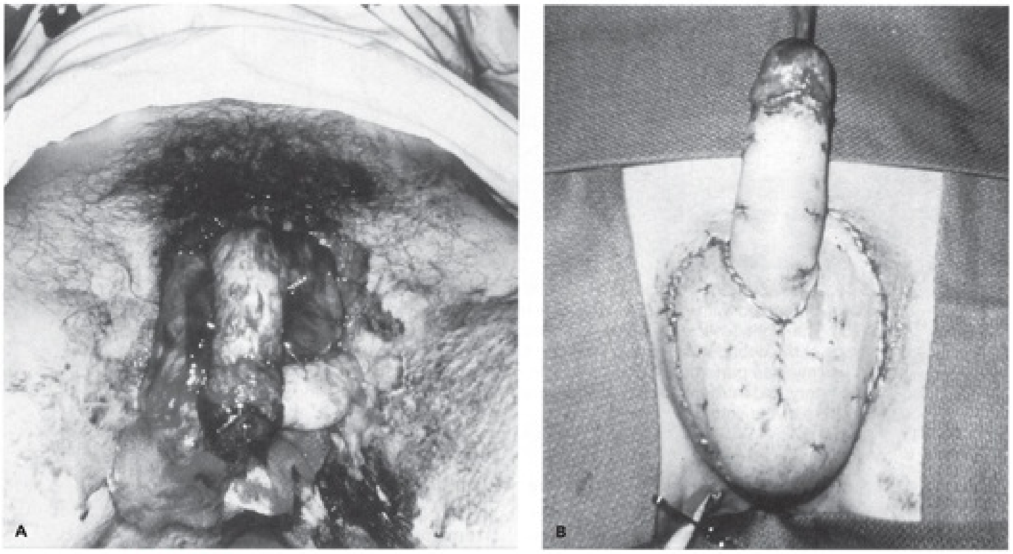

FIGURE 63.12 **A:** Large avulsion injury of the genitalia. The patient was injured when his clothing was ensnared in the power takeoff mechanism of a tractor. Note the exposed shaft of the penis and the exposed testicles bilaterally. **B:** The appearance after reconstruction with an STSG. The patient was observed for 24 hours, allowing the wounds to demarcate. In this case, both the shaft of the penis and the scrotum were reconstructed with a sheet STSG.

If a primary closure cannot be accomplished with the remaining scrotal tissue, then the surgeon has several options. One option is to place the testicles in thigh pouches to be later liberated and replaced to the area of the scrotum. The preferable option is to perform a primary reconstruction of the scrotum using a contiguous, meshed, STSG. Air-driven dermatomes work best for STSG harvest, and either 2- or 3-inch wide blades perform the best. The graft should be harvested 0.016 to 0.020 inch thick (thicker STSGs minimize contracture by transporting more collagen and elastin and generally provide for better cosmetic results, except in the case of lymphedema secondary to systemic disease, that is, “Charles disease,” secondary to pelvic irradiation in which case a thin graft 0.012 to 0.014 inch is preferable) and then meshed to a 1.5- to 1.0-inch or a 1:1 ratio. The testicles must be sutured together and fixed in midline position using permanent suture or absorbable suture that is slowly absorbed so that they do not migrate beneath the graft. Likewise, in cases of Fournier gangrene, where the testicles are left exposed and grafting may be delayed for 7 to 10 days, it is very important to suture the exposed testicles together to prevent torsion during the dressing changes. The meshing of the graft will increase its surface area, allow for escape of serum and blood products from beneath the graft, allow the graft to configure better to the complex contours of the underlying testicles, and provide a final cosmetic result resembling the natural scrotal rugation. When applying the skin graft, 4-0 or 5-0 chromic suture is preferable. To avoid lifting the graft off of its bed, one should start suturing by first passing the suture through the graft. That is, suture from graft to the skin edge or deep tissue. This will peg the graft into place and make suturing easier by preventing the graft from being lifted off of its bed. The sutures should be placed through the skin tissue bridges of a meshed graft and not through the holes in the meshed graft. For best results, sutures should be placed 0.5 cm to 1 cm apart. The tunica vaginalis space can be left open, and the graft is then applied immediately to the tunica albuginea of the testicles, suturing it to the surrounding skin, or closed. It is our personal opinion that the graft takes better and the cosmetic results are superior in cases where the tunica vaginalis can be preserved and the graft applied to the tunica vaginalis rather than the tunica albuginea. As is typical in reconstructive surgery, we learn to work with whatever healthy tissue we have remaining. It is the opinion of some authors that grafting directly on the visceral tunica vaginalis or tunica albuginea can lead to a situation where there is chronic testicular pain. In order to avoid this complication, when suturing the testicles together, it is important to take superficial bites of the cremaster fibers and avoid deep bites which could incorporate nerves. This has not been the author’s (GHJ) experience. Unless the wound is markedly contaminated, cases so managed have yielded very successful results.

In cases of genital grafts, the dressing is of utmost importance. The grafts should be bolstered using Xeroform gauze or one of the other commercially available fine-meshed gauzes applied directly to the graft, with Dacron batting soaked in mineral oil placed over the finely meshed gauze. Lately, we have favored the use of the high-density polyethylene sheeting (N-TERFACE, Winfield Laboratories, Inc, Richardson, Texas) to prevent adherence and subsequent graft displacement with bolster removal. The bolster is held in place with 4-0 chromic sutures. Unless there is an associated urethral injury, the patient can be “diverted” with a soft Foley catheter. In patients in whom the avulsion injury extends near to the anus, colostomy may be required to prevent wound soilage. It must be emphasized that local skin flaps are not recommended for primary closure in these cases.

In patients in whom the avulsion injury is tantamount to emasculation, these injuries are often associated with significant injuries to the adjacent tissue. Reconstruction assumes a very secondary position, as these patients require lifesaving steps. The vast majority of these patients will require colostomy, suprapubic cystostomy, and multiple dressing changes over the posttrauma course, and they often present with significant bleeding.

In general, the scrotal skin is highly distensible, and even a small fragment can be expanded to cover a large defect with a good functional result because the testicles serve as natural tissue expanders. Even in cases where 60% of the scrotal tissue is lost, primary reapproximation can still be performed. There has been concern regarding the effect of implantation of the testes in thigh pockets on spermatogenesis, although there are few clinical data to support this concern. When performing testicular thigh pouches, a large enough space deep to the subcutaneous fat and superficial to the fascia lata of the thigh should be created so that a standard surgical lap pad can easily fit into this space. A slightly anterior position for testicular placement is preferable. If placed too posteriorly, the patient tends to sit on the testicles, and because many patients requiring testicular thigh pouches are obese, diabetic patients with Fournier gangrene, if placed too medial, the testicles can rub together during ambulation. Hence, we prefer a slightly anterior placement.

Genital Burns

The emergency therapy of genital burns is similar to that for any burn. The scrotum can be dressed, open, with topical antibiotic ointments such as Silvadene, or a closed antibiotic dressing regimen can be used. The integrity of the urethra must be determined when the patient presents. A Foley catheter can be placed in the patient who has burns to his genitalia. If there is evidence of urethral burn, then most would suggest diversion with suprapubic cystostomy. If the burns to the genital and perineal area are extensive, then an occasional patient will require colostomy. If the subscrotal urethra is involved in the burn, no attempt at initial reconstruction should be made. In the case of the infant or young male, the move to a suprapubic tube should be made quickly if the need for a urethral catheter is at all prolonged.

In the case of severe genital burns, a suprapubic cystostomy can be placed in its typical location even if the suprapubic area is also badly burned. If a urethral Foley catheter is used, it is important to continually reassess the necessity of the urethral Foley and to keep the penis secured to the abdomen in the anatomic position. Pressure from prolonged urethral catheterization of the edematous, compromised genital tissue, especially when the catheter is positioned in the customary dependent position and secured to the leg can result in pressure necrosis of the ventral urethra and urethral-cutaneous fistula. If the urethra is involved, either from the initial burn or as a result of delayed pressure necrosis, the urine is best diverted through a suprapubic cystostomy and urethral reconstruction delayed.

The genital tissues are remarkably vascular. Debridement of the genitalia, in general, should be accomplished carefully. Aggressive debridement should be avoided, as many of the tissues will recover and are nonreproducible. Whirlpools and tank soaks are useful for gentle debridement and cleansing, and they may be done early on, two to three times per day.

Chemical burns rarely involve the structures deep to the skin and are managed with copious irrigation and then as with a thermal burn (LOE 4). If a patient has evidence of an electrical burn to the area of the genitalia, the patient must be observed for 12 to 24 hours and then explored. In electrical burns, the initial management is aimed at debridement, and reconstruction can be offered later as the situation dictates (Fig. 63.13).

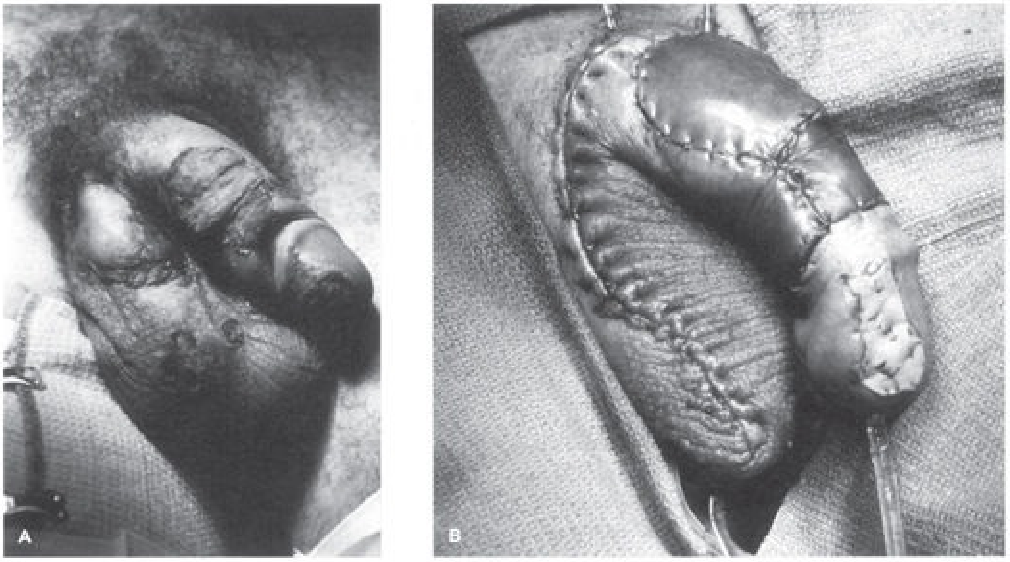

FIGURE 63.13 **A:** The appearance of the genitalia in a patient who was burned in a steam-line accident. Note the burns to the glans, the dorsum of the shaft of the penis, and the right hemiscrotum. **B:** In this particular case, reconstruction of the glans was accomplished with a small STSG. Reconstruction of the shaft of the penis was accomplished with a penile skin island flap; the patient was uncircumcised, and the ventral skin was mobilized to the dorsum. The scrotal burn was completely excised, and primary reconstruction of the right hemiscrotum was accomplished. This particular patient demonstrates all of the possibilities for reconstruction following burn debridement.

Radiation Injuries

In the case of scrotal lymphedema and recurrent cellulitis, all layers of the scrotum should be excised to the level of the external spermatic fascia (Fig. 63.14). It is not uncommon for the patient also to have large hydroceles due to lymphatic occlusion (5).

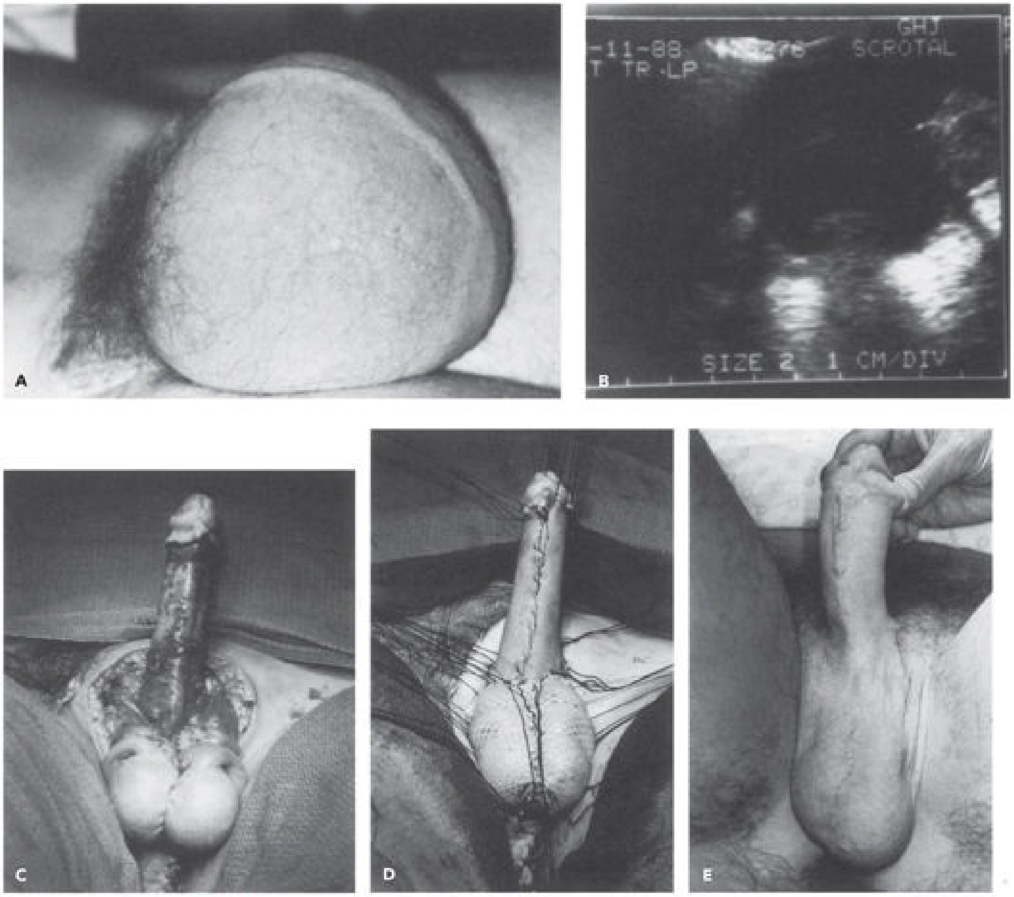

FIGURE 63.14 Appearance of a young man with chronic genital lymphedema following irradiation therapy for Hodgkin lymphoma. **A:** Appearance of the massively lymphedematous scrotum. **B:** B-scan ultrasound demonstrating the large hydrocele. Note the normal testis posteriorly. **C:** Appearance of the genitalia after debridement of the lymphedematous tissue. Note that orchidopexy has been performed. **D:** Immediate appearance following reconstruction of the shaft of the penis with an STSG and reconstruction of the scrotum with a meshed STSG. **E:** Appearance of that same patient 6 months postoperatively. Note the small amount of residual lymphedema of the preputial cuff. Further note the redundant appearance of the scrotal graft.

The tunica vaginalis space should be opened and the parietal tunica vaginalis then reflected and incorporated in the orchidopexy. Reconstruction can be accomplished, using a thin STSG (0.012 to 0.014 inch thick), as already discussed, and on the scrotum, these grafts can be meshed as discussed earlier. In addition, the meshing seems to improve the cosmetic result by giving the appearance of the normal scrotal rugations (6). Full-thickness skin grafts should not be used. The cosmetic results achieved in these patients, so reconstructed, are excellent. The use of lateral scrotal flaps as mentioned previously is worthy of consideration in properly selected patients (Fig. 63.15). Radiated patients in general are not candidates because the problem is with the “systemic” lymphatic drainage and not just the lymphatics of the skin per se.

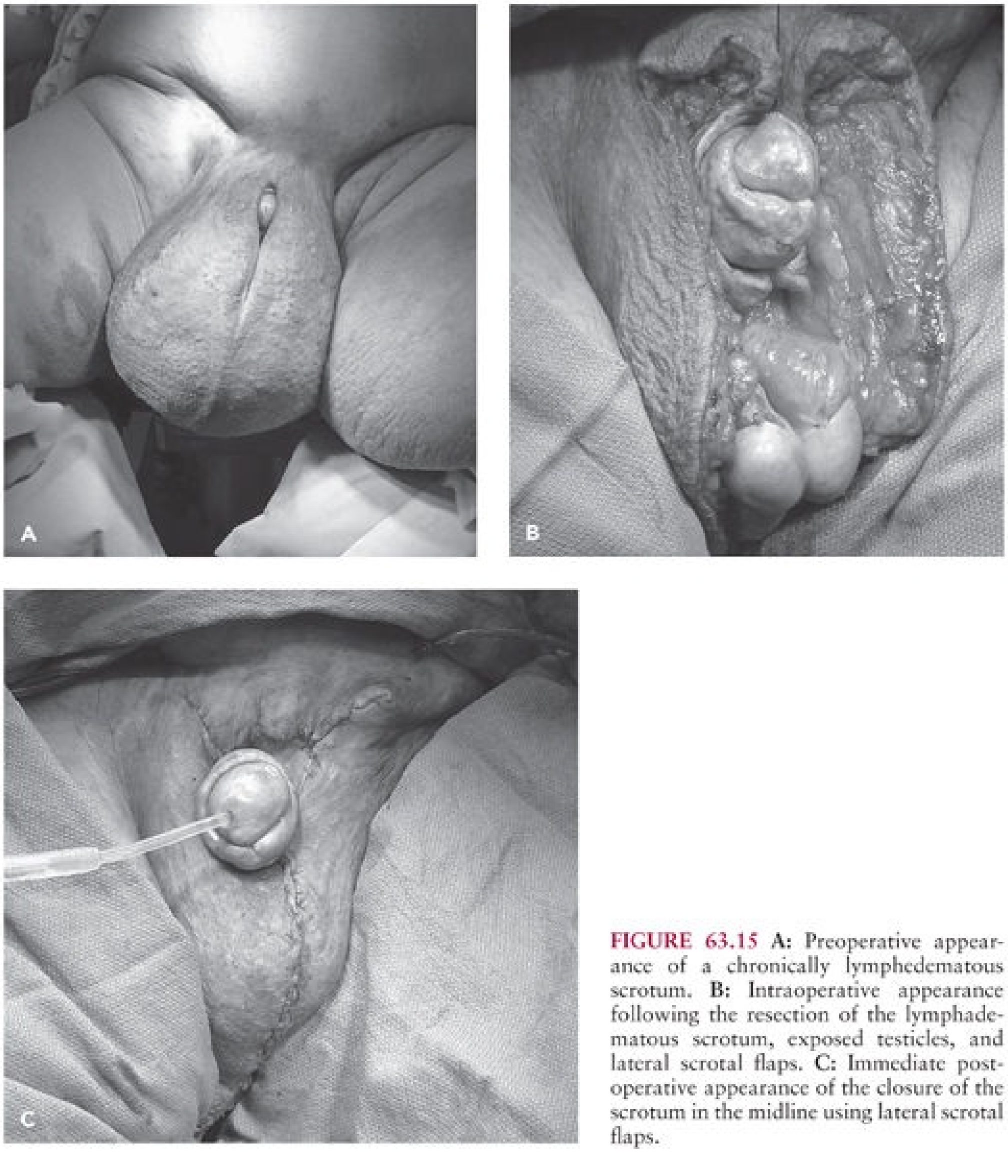

FIGURE 63.15 **A:** Preoperative appearance of a chronically lymphedematous scrotum. **B:** Intraoperative appearance following the resection of the lymphadematous scrotum, exposed testicles, and lateral scrotal flaps. **C:** Immediate postoperative appearance of the closure of the scrotum in the midline using lateral scrotal flaps.

Fournier Gangrene

If the primary process has resulted in extensive debridement of the scrotum, the testicles can be placed in thigh pouches with the intention of later replacing the testicles in their normal anatomic area and for scrotal reconstruction. The author's (GHJ) preferred approach was described by McDougal and Persley (7) and is illustrated in Figure 63.16. The lateral defects on the thigh can often be closed primarily or can be grafted (7,8).

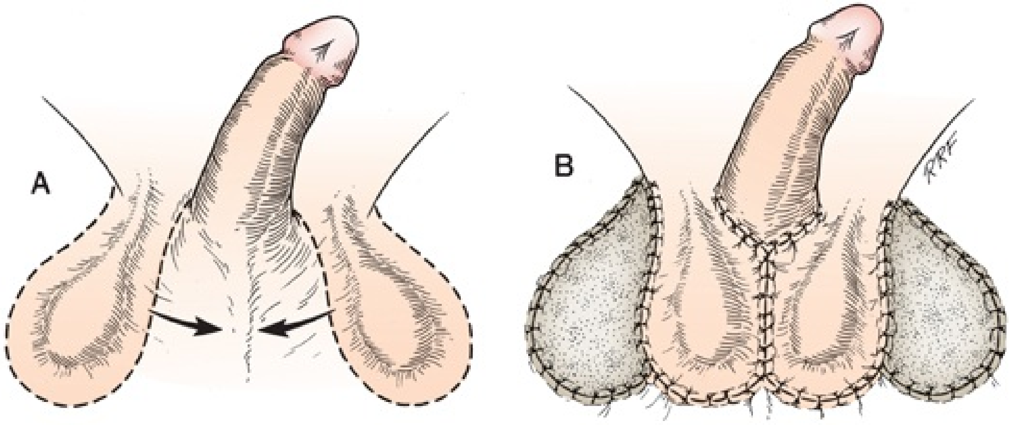

FIGURE 63.16 Technique after McDougal for liberation of testicles that have been placed in thigh pouches. Note that the testicles are mobilized with random thigh skin flaps and transposed to the midline to reconstruct the scrotum. The lateral defects can be closed per primam or can be grafted. The *arrows* indicate medial rotation of lateral thigh flaps after liberation of the testicles from thigh pouches.

For most patients, however, the scrotal excisions do not necessitate placing the testicles in thigh pouches, but instead they can be dressed in the wound (9). These patients often require multiple dressing changes and wet-to-dry debridements. These techniques can be used in combination with negative pressure dressings or vacuum-assisted closure (VAC) devices to reduce the defect size more quickly, although it can be difficult to obtain a good seal when using vacuum-assisted devices on the scrotum or testicles and the negative pressure can cause testicular pain. When reconstruction is undertaken, the testicles must be fixed in their normal anatomic position. It is our custom to open the parietal tunica vaginalis and reflect it, and, as already described, graft techniques can be utilized to restore the scrotum. Although local flaps can be used, the cosmetic results achieved with local flaps are usually less than optimal in most of these circumstances when compared to reconstruction techniques utilizing STSGs. Interestingly, these mesh STSGs not only remain supple but in many cases (as has been shown) will actually become redundant because the testicles themselves serve as natural tissue expanders.

OUTCOMES

Complications

Complications of scrotal trauma and reconstruction are primarily related to inadequate appreciation of the degree of injury with subsequent necrosis of additional skin. It is important for the surgeon to adequately debride the devitalized skin, which may require more than one trip to the operating room. The failure of a skin graft to take is usually a result of technical errors, infection, the accumulation of fluid under the graft, an inadequately prepared poor graft bed, or sheering forces with continual slippage of the graft over the bed, which does not allow capillary ingrowth. In order to prevent these complications, we perform proper and thorough debridement and preparation of the graft bed, provide appropriate antibiotic coverage, mesh the graft at a 1:1 ratio, utilize a sufficient number of suture to contour the graft and secure the graft into place, and apply bolster dressing, additionally weeks our patients on bedrest for 5 days postoperatively in order to to protect against graft loss secondary to motion and sheering forces.

Results

As with most surgical conditions, prompt diagnosis and management of acute testicular injuries is paramount to maintaining testicular function. Burns, avulsion, and radiation injuries require aggressive debridement of devitalized tissue to minimize infection and to prepare a healthy graft bed. Reconstruction of the scrotal skin, most often performed with meshed STSG, offers excellent graft take and survival with acceptable cosmetic results in closing the resultant defect.

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SECTION VI ■ PENIS AND SCROTUM

Section Editor: RAMÓN VIRASORO

CHAPTER 64 ■ PENILE AND SCROTAL ANATOMY

JONATHAN N. WARNER AND RICHARD A. SANTUCCI

PENILE ANATOMY

Structure

The penis is composed of the corpus spongiosum, the paired corpora cavernosa, and the glans penis (Fig. 64.1). Each of the three corporal bodies is attached to the pelvis. First, the paired crura of the corpora cavernosa are firmly adherent to the inferior edge of the pubic arch. These dense fibrous chambers extend distally until the level of the pubic symphysis, where the two crura join at the penile hilum to form the dorsal aspect of the pendulous portion of the penis.

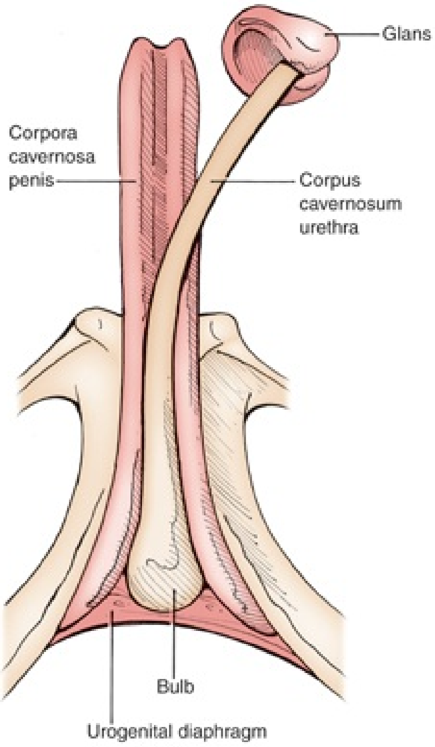

FIGURE 64.1 Anatomy of the three corporal bodies comprising the penis.

The corpus spongiosum begins proximally as the dilated bulb and then tapers to join the ventral side of the corpora cavernosa at the hilum, completing the pendulous portion of the penis. Proximally, the bulb is adherent to the central tendon, securing it to the perineal body. The bulb can be accessed through a perineal incision as in artificial urinary sphincters, male slings, and bulbar urethroplasties (Fig. 64.2). Distally, the spongiosum dilates into the glans penis, which covers the tips of the corpora cavernosa completing the glans portion of the penis. The most proximal part dilates circumferentially forming the corona of the glans. Each of the three chambers has its own blood supply and can be dissected from the other for complex epispadias repair (Fig. 64.3).

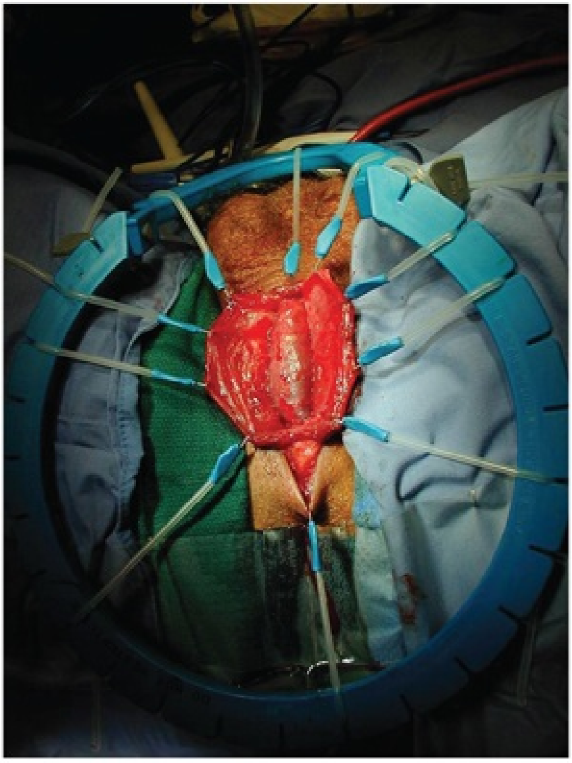

FIGURE 64.2 Perineal dissection showing the bulbar urethra, note the dissected and split bulbocavernosus (bulbospongiosus) muscle.

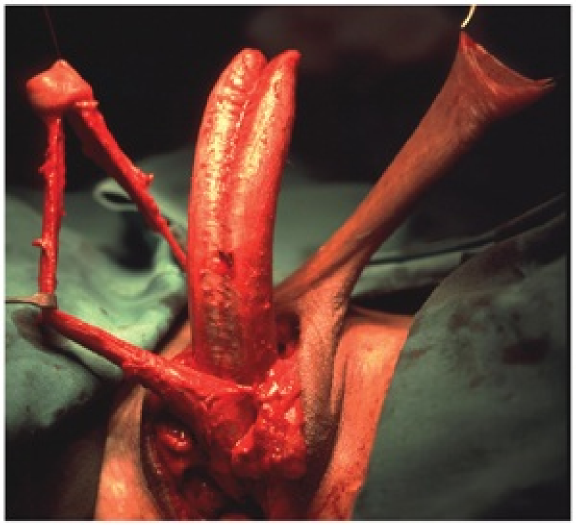

FIGURE 64.3 Complete penile disassembly during a complex epispadius repair. This highlights the completely separate blood supply of (a) each corpora, (b) skin, and (c) corpora spongiosum (including urethra and glans cap). (Photo courtesy of Dr. Miro Djordjevic.)

The outer layer of each corpora is called the tunica albuginea. The tunica of the cavernosa is a dense two-layered fibrous structure. The paired cavernosa share a common outer longitudinal sheath and an inner circular sheath that is only shared at the medial surface. The shared medial surface is called the septum (Fig. 64.4). The tunica is the layer inflicted by scar and plaque in Peyronie disease (Fig. 64.5), believed to occur between the two layers, commonly at the septal insertion (1). Conversely, the tunica of the spongiosum is only composed of a circular layer and is thus much thinner than that of the corpora cavernosa.

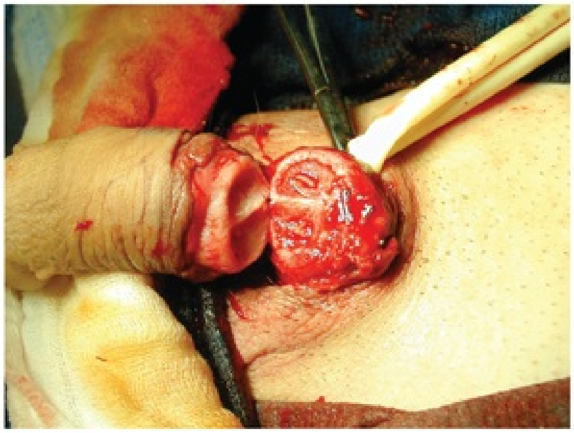

FIGURE 64.4 Penile amputation showing the corpora cavernosa, septum, and erectile tissue. The cavernosal arteries, dorsal artery, and dorsal vein have been clipped during repair. The urethra (not seen) has been repaired.

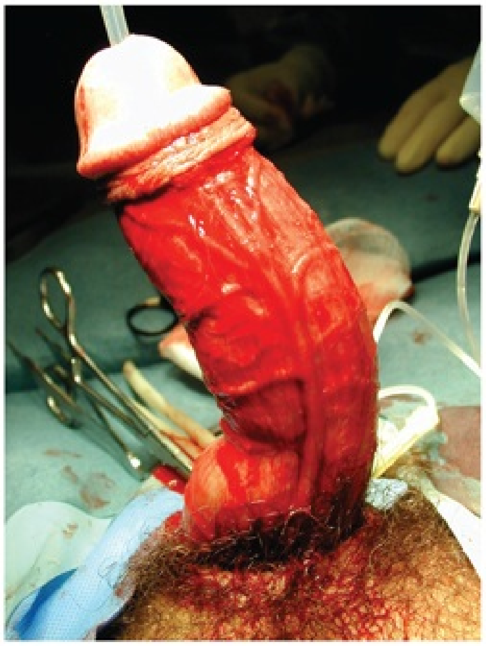

FIGURE 64.5 Degloved penis showing left lateral curvature due to Peyronie plaque in the tunica albuginea. Note normal superficial dorsal vein anatomy and the subtle appearance of the penile dorsal nerves.

Buck fascia covers the two cavernosal bodies and then splits ventrally to encircle the spongiosum. In the perineum, Buck fascia fuses with the tunical layer. Covering the crural fascia is the ischiocavernosus muscle. This muscle compresses the erectile bodies, potentiating an erection. The fascia of the bulb of the spongiosum is covered by the bulbocavernosus muscle. When contracted, this muscle will also potentiate an erection but further acts to express semen and urine. Distally, Buck fascia fuses with the corona of the glans. This margin can be accessed to insert malleable prosthesis for erectile dysfunction. Fibers from the pubic symphysis fuse with the dorsal aspect of Buck fascia forming the suspensory ligament.

Buck fascia is covered by a loose connective tissue called dartos fascia. Dartos fascia is in communication with Colles fascia of the perineum, Scarpa fascia of the abdomen, and the dartos layer of the scrotum (Fig. 64.6). Thus, injury deep to Buck fascia, as in penile fractures, will result in a hematoma confined to the penis (Fig. 64.7), whereas injury to the tunica and Buck fascia will have the potential to spread into the perineum, laterally to the fascia lata, and cephalad over the abdominal wall (Fig. 64.8). The dartos layer allows the skin to move freely over the shaft of the penis.

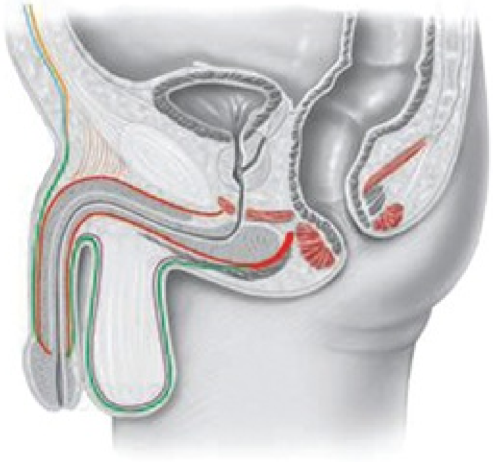

FIGURE 64.6 Diagram of sagittal section showing the fascial planes of the male external genitalia, perineum, and lower abdomen. (From Hohenfellner M, Santucci RA. *Emergencies in Urology*. Heidelberg, Germany: Springer, 2007. © Copyright, 2007 Dr. Markus Hohenfellner, with permission.)

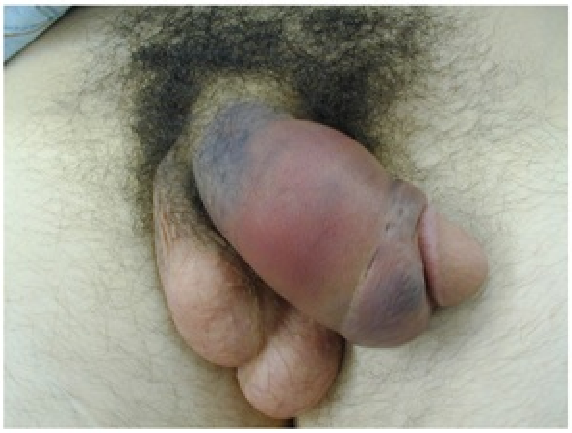

FIGURE 64.7 Penile hematoma consistent with penile fracture deep to Buck fascia.

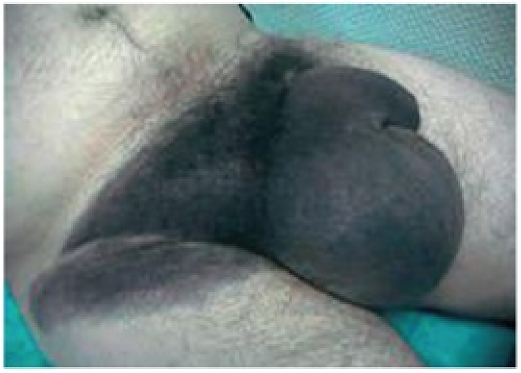

FIGURE 64.8 Pelvic fracture consistent with injury to Buck fascia confined deep to the dartos, Colles, and Scarpa fascia.

The skin of the penis is thin, devoid of fat and hair, and highly elastic. The only glands are those that produce smegma at the coronal margin. At this margin, the penile skin folds over itself covering the glans and forming the foreskin or prepuce. The inner surface of the prepuce is thinner than the outer surface. The skin thickness distinction is important when performing a circumcision because one wants to leave a margin of the inner, thin layer intact to secure to the outer thicker layer. The frenulum of the prepuce is located ventrally and medially, extending from the corona to the urethral meatus of the glans. The frenulum is the most distal component of the median raphe, which extends from the urethral meatus down the shaft of the penis, over the medial scrotum and to the perineum. The median raphe serves as a good entry point to the underlying structures. The skin of the glans is tightly adherent to the underlying tunica of the spongiosum and clinically indistinguishable. This layer can be divided to gain access to the tip of the cavernosa as may be necessary when performing a cavernoglandular shunt for priapism (2). Correction of priapism may also require a perineal approach, so the proximal bulb may be anastomosed to the cavernosum allowing the blood to flow out of the cavernosa into the spongiosum (Fig. 64.9).

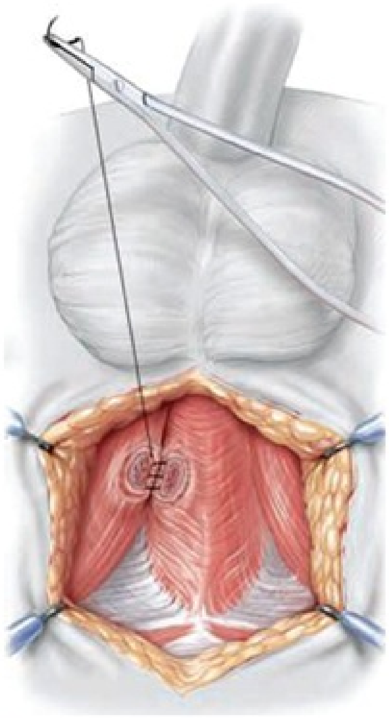

FIGURE 64.9 Cavernosospongiosal shunt highlighting the different venous drainage of the corpora cavernosa and the corpora spongiosum of the penis. (From Hohenfellner M, Santucci RA. *Emergencies in Urology*. Heidelberg, Germany: Springer, 2007. © Copyright, 2007 Dr. Markus Hohenfellner, with permission.)

The paired chambers of the corpus cavernosa envelope erectile tissue, which serves to produce a rigid penis during an erection. The thick tunica of the cavernosa is capable of holding high pressures, ensuring a firm erection. The erectile tissue is supported by trabeculations extending from the inner sheath to the septum. The trabeculae are composed of elastic fibers, arteries, and smooth muscle fibers. The gross appearance is spongy due to the trabeculae. The arterial branches, called the helicine arteries, either open directly into the endothelial lined sinusoids or supply the stroma of the erectile tissue. Distally, the septum between the two chambers of the cavernosum is incomplete, allowing communication of the sinusoids. This is why during penile injection with vasoactive agents only one chamber needs to be injected.

The corpus spongiosum supports the anterior urethra. Beginning in the dilated bulbar urethra at the level of the perineal body, it tapers near the penile hilum to the pendulous urethra and then dilates again at the fossa navicularis before reaching its narrowest point at the meatus. The spongiosum and the glans also contain erectile tissue. The sinusoids are larger, and the tunica is much thinner. Therefore, the spongiosum does not play as vital role in the rigidity of an erection. Instead, the glans provides a cushion from the underlying rigid cavernosal bodies. In addition, the glans is rich in nerve endings aiding in stimulation. An anterior urethral stricture often occurs when there has been scarring to the spongiosal erectile tissue and the urethral mucosa resulting in a narrow lumen (Fig. 64.10).

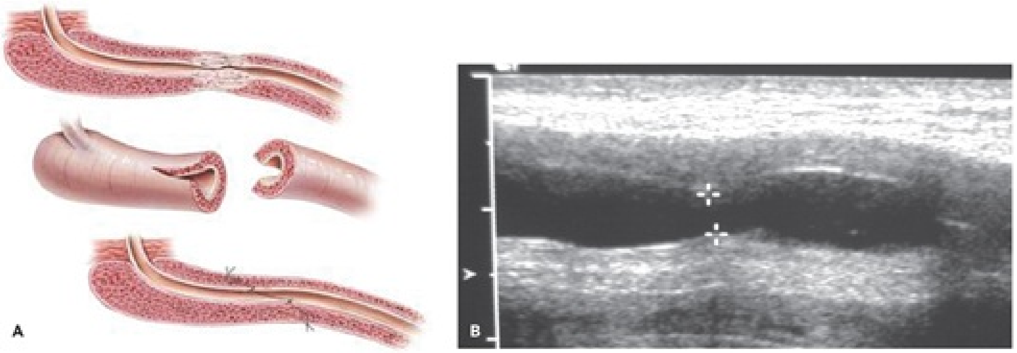

FIGURE 64.10 **A:** Urethral stricture, showing urethral lumen narrowing and spongiofibrosis, treated with excision and anastomosis. (From Hohenfellner M, Santucci RA. *Emergencies in Urology*. Heidelberg, Germany: Springer, 2007. © Copyright, 2007 Dr. Markus Hohenfellner, with permission.) **B:** Ultrasound findings of a urethral stricture showing urethral lumen narrowing.

Blood Supply and Lymphatics

The internal pudendal artery, a branch of the internal iliac artery, travels through Alcock canal and sends the inferior rectal artery, posterior scrotal artery, and the perineal artery. Alcock canal, and its contents, is a common test question for urologists. The internal pudendal artery then terminates as the common penile artery. Three branches arise from the penile artery (Fig. 64.11). The bulbar artery pierces the spongiosum near the perineal body at the posterolateral margin and supplies the urethra, the spongiosum, and the glans. The second branch is the cavernosal artery that pierces the dense sheath at the penile hilum and travels in the center of the erectile tissue where it branches to supply the sinusoids (Fig. 64.12). Finally, the dorsal artery of the penis passes between the crura and inferior to the pubic bone to run deep to Buck fascia where it sends circumflex branches to the spongiosum and cavernosal branches to aid in erections. Additionally, there is often an accessory pudendal artery originating from the obturator or inferior vesical artery, which passes anterolateral to the prostate and then under the pubic arch with the dorsal vein (3). These accessory branches may be vital to erectile function, and if compromised or sacrificed during prostatectomy, the patient may be rendered impotent. The arterial supply to the penile skin is based on the external pudendal artery, a branch of the femoral artery (4). These branches are vital to perform fasciocutaneous flaps for penile reconstruction (Fig. 64.13).

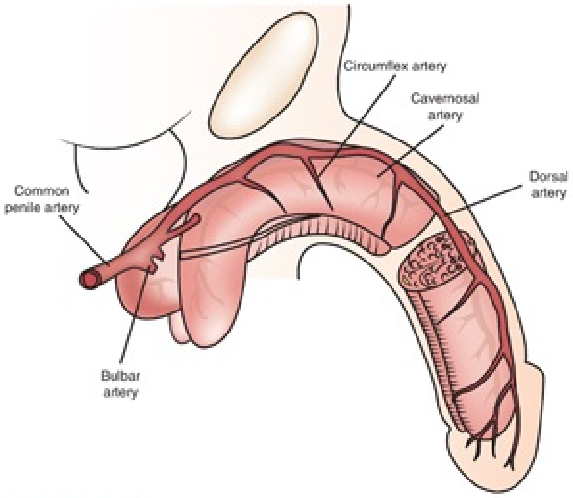

FIGURE 64.11 Illustration of the common penile artery and the three branches: bulbar artery, cavernosal artery, and the dorsal artery.

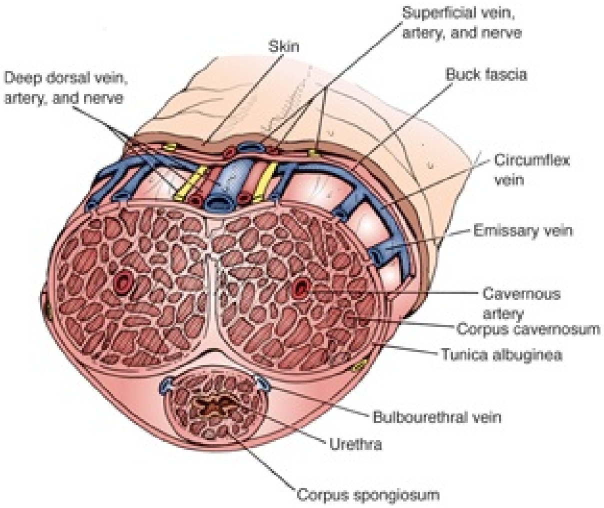

FIGURE 64.12 Cross section of the penis demonstrating the fascial layers as well as vascular and neural anatomy.

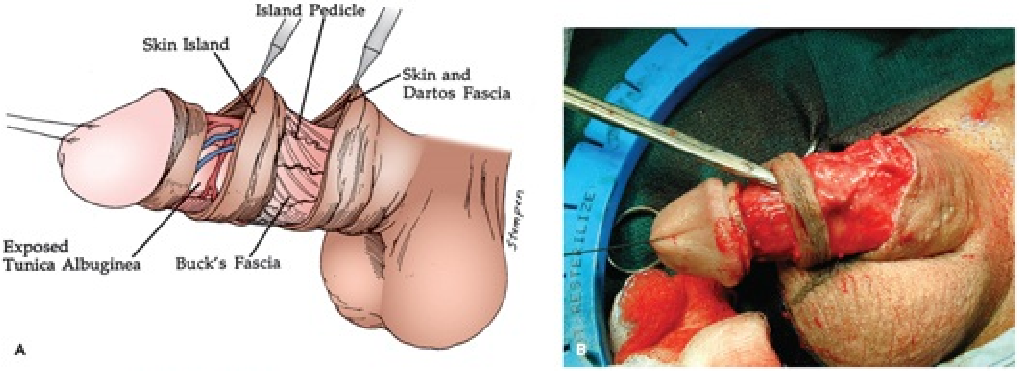

FIGURE 64.13 A: Diagram of a fasciocutaneous flap for use in urethral reconstruction. B: Operative demonstration of fasciocutaneous flap. The flap is dissected off the tunica albuginea (*below*) and then the penile skin (*above*) is carefully dissected off the dartos layer, preserving it. The flap's blood supply is found in the intact dartos layer.

The venous drainage of the penis is divided into the superficial dorsal system, the deep dorsal system, and the crural vessels (Fig. 64.14). The deep dorsal vein begins at the base of the glans in the retrocoronal plexus. From here, the dorsal vein travels deep to Buck fascia between the paired dorsal arteries. Along its path, it receives circumflex veins from the spongiosum until it travels under the pubic bone and joins the periprostatic plexus. The cavernosal sinuses drain to a subtunical venous plexus, which then sends emissary veins through the tunica of the cavernosa to join the circumflex veins. The emissary veins travel at an oblique angle through the tunica and are compressed during an erection to aid in blood trapping within the cavernosa. The circumflex veins are found in the distal two-thirds of the penis only. More proximally, at the hilum and the crura, the emissary veins coalesce to form the cavernosal veins and crural veins, respectively. These veins then pass between the bulb and the crura to drain into the periprostatic plexus or the internal pudendal vein. The superficial dorsal vein drains the skin of the penis and ultimately empties in the superficial external pudendal vein and then to the saphenous vein (Fig. 64.15).

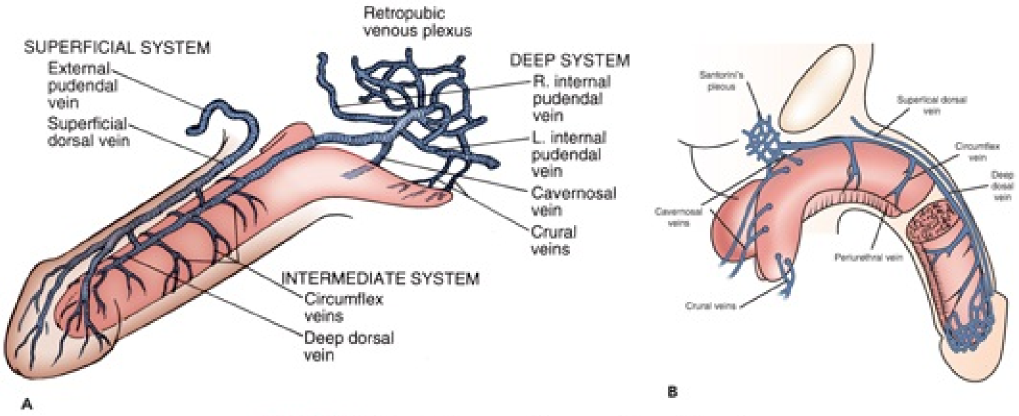

FIGURE 64.14 **A and B:** Diagrams of the venous drainage of the penis.

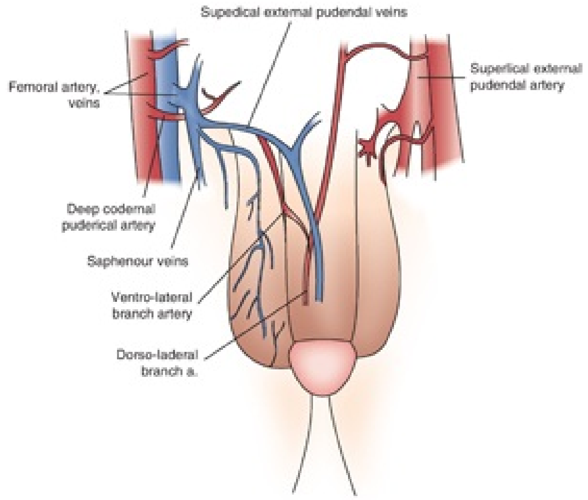
Supedical external pudendal veins
Femoral artery, veins
Superfical external pudendal artery
Deep codemal puderical artery
Saphenour veins
Ventro-lateral branch artery
Dorso-laderal branch a.

FIGURE 64.15 Superficial arterial and venous drainage of the penis and scrotum.

The lymphatic drainage of the penis is primarily to the superficial inguinal lymph nodes. There is no reliable laterality of the lymphatic drainage of the penis. This becomes important in penile cancer cases, mandating bilateral lymphadenectomy when indicated.

Innervation

The pudendal nerve travels through Alcock canal and enters the perineum posterior to the ischial tuberosity. The tuberosity can be used as a landmark to perform a pudendal nerve block. With a finger in the rectum, the tuberosity can be palpated. Using a long 20-gauge needle popped deep to the sacrospinous ligament and posteriorly, laterally, and medially to the tuberosity, 10 to 15 mL of local anesthetic can be injected bilaterally to numb the entire perineum and penis.

The bulbospongiosus muscle and the ischiocavernosus muscles are innervated by the deep branch of the perineal nerve, a branch of the pudendal nerve. The pudendal nerve then terminates in the dorsal nerve of the penis which runs lateral to the artery beneath Buck fascia. The dorsal penile nerve supplies the majority of the skin of the penis and the glans. This nerve is targeted for a penile block by placing a needle at the junction of the pubic bone and cavernosal bodies, deep to Buck fascia at the 10 and 2 o’clock position (Fig. 64.16A and B). After aspiration, up to 10 mL of local anesthetic can be injected. This will control the majority of the nerve supply to the penis. The skin of the base of the penis is supplied partially by branches from the ilioinguinal nerve. A superficial ring block can target these nerves not covered by the penile nerve block. It is important to remember that epinephrine containing anesthetics should be avoided in the penis.

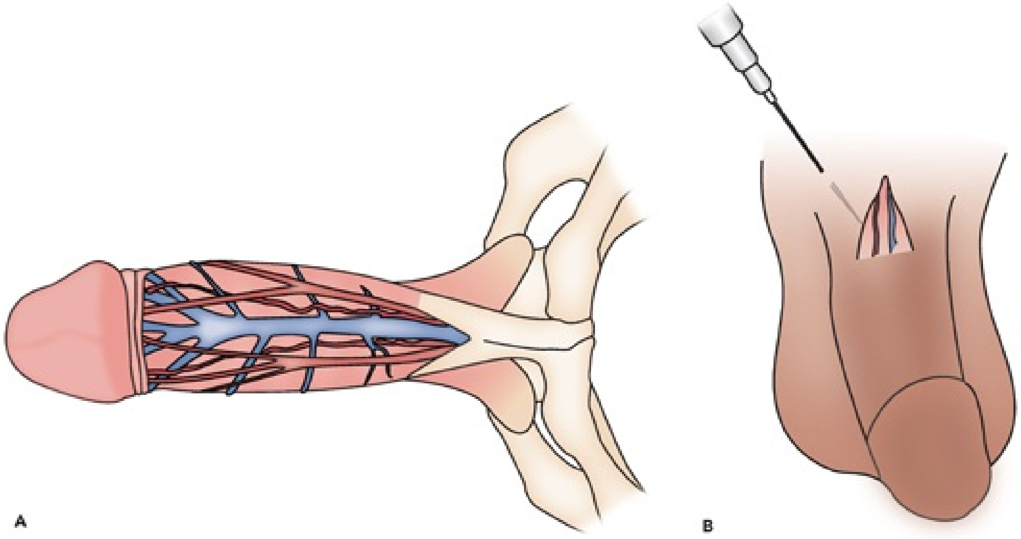

FIGURE 64.16 Diagram of penile nervous anatomy and penile block. A: Dorsal view of penile neurovascular bundle. B: Penile block at 2 and 10 o'clock position

The cavernous nerve carries autonomic fibers, running posterolateral to the prostate, and piercing the pelvic floor where it then penetrates the crura and innervates the erectile tissue. The sympathetic component leads to constriction and maintains a flaccid state. The parasympathetic fibers allow smooth muscle and endothelial relaxation contributing to filling of the sinusoids, ultimately leading to an erection.

SCROTAL ANATOMY

Structure

The scrotum serves as a fibromuscular sac to support the testes. It lies posterior and inferior to the penis, beginning at the level of the pubic symphysis and ending at the midperineum. The layers of the scrotum are based on those of the abdominal wall. However, these layers are difficult to discern clinically. These layers can be simplified into the skin, the dartos, and the tunica vaginalis. The dartos layer of the scrotum contains smooth muscle fibers to control the tone of the scrotal skin. The tunica vaginalis layer surrounds the testicle in a parietal and visceral mesothelium-lined sac that has a thin layer of fluid between to allow the testicle to move freely other than the posterolateral attachments. Excess fluid in the layer between the parietal and visceral tunica vaginalis results in a hydrocele. At the posterolateral surface of the testicle, it is adherent to the wall of the scrotum at its mesentery. Inferiorly, the testicle is adherent to the scrotum via the gubernaculum. If the attachments are absent, the testicle may be free to rotate around its central axis resulting testicular torsion (Fig. 64.17).

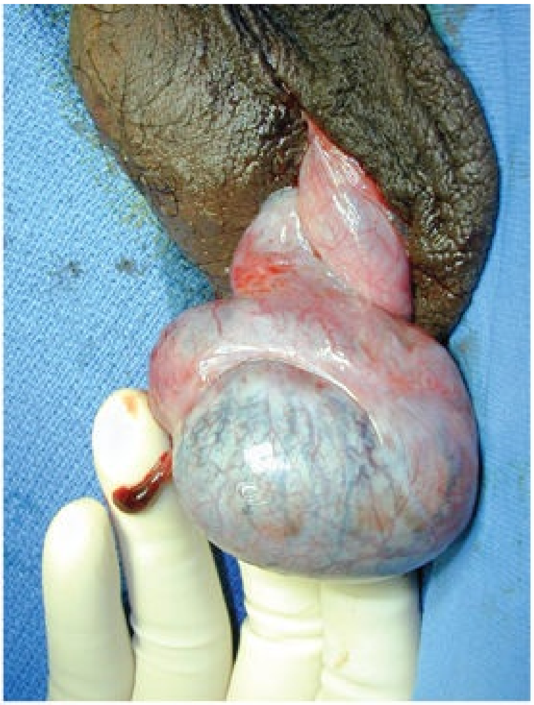

FIGURE 64.17 Testicular torsion, note the twisting of the cord. Also showing an incidental appendix epididymis.

Deep to the visceral layer of tunica vaginalis is the tunica albuginea of the testicle. At the posterolateral margin, the tunica albuginea is covered by the epididymis. Here, the tunica invaginates into the testicle, creating the mediastinum. Many septa extend from the mediastinum creating multiple lobules to encompass the seminiferous tubules. These tubules combine and expand near the mediastinum to form the efferent ductules in a network known as the rete testis. The ductules then enter the head of the epididymis, where they further enlarge, and ultimately end in the single convoluted epididymal duct, that forms the body and tail of the epididymis. Near the end of the tail of the epididymis, the epididymal duct thickens and expands to form the vas deferens (Fig. 64.18A and B). An epididymal cyst forms when the duct becomes enlarged. The vas deferens extends from the base of the testicle and passes superiorly as part of the spermatic cord. The spermatic cord also consists of the testicular artery, the pampiniform plexus, the internal spermatic fascia, cremasteric muscle fibers and fascia, and the external spermatic fascia (Fig. 64.19). During a vasectomy, the vas deferens is divided in the upper scrotum as it runs with the spermatic cord after dissecting the surround muscle and fascia off the vasa. Two commonly encountered embryologic remnants are the appendix epididymis and the appendix testis. The appendix epididymis is a remnant of the Wolffian duct, whereas the appendix testis is a remnant of the müllerian duct. These structures can twist and cause acute testicular pain mimicking testicular torsion. If they are encountered during scrotal surgery, it is common practice to fulgurate the structures to prevent future torsion (see Fig. 64.17).

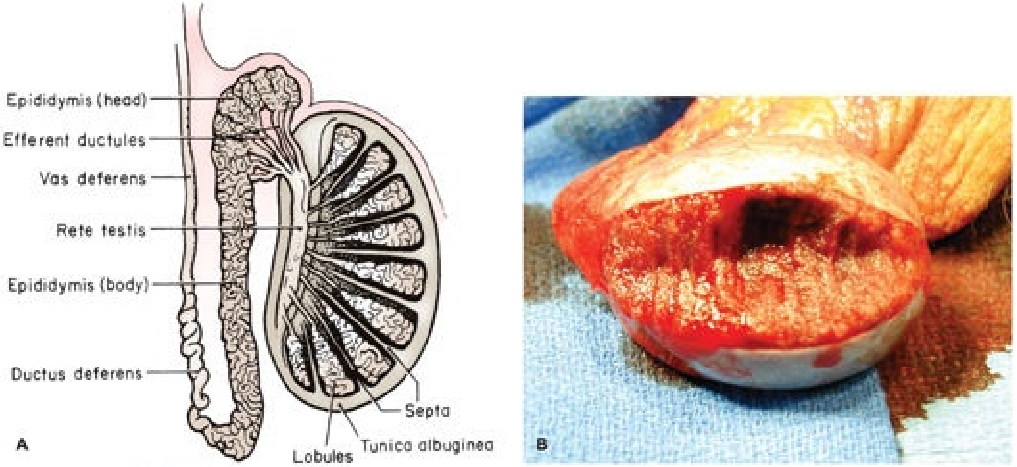

FIGURE 64.18 A: Cross section of the testicle. B: Testicular debridement after gunshot wound showing the septa and lobules of seminiferous tubules.

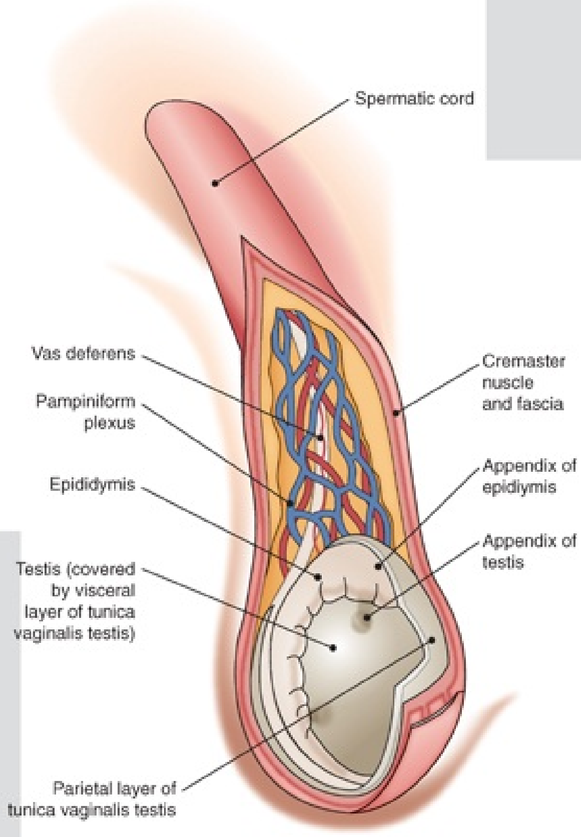
Spermatic cord
Vas deferens
Pampiniform plexus
Epididymis
Testis (covered by visceral layer of tunica vaginalis testis)
Parietal layer of tunica vaginalis testis
Cremaster nuscle and fascia
Appendix of epidiymis
Appendix of testis

FIGURE 64.19 Scrotum and spermatic cord.

Blood Supply and Lymphatics

The posterior scrotal artery branches from the perineal artery, described earlier. The anterior scrotal artery is a branch of the external pudendal artery, a branch of the femoral artery. The vessels of the skin of the scrotum run parallel to the rugae and do not tend to cross the raphe. Given the path of the blood supply, transverse and medial incisions along the raphe will tend to have less bleeding (see Fig. 64.15).

The blood supply of the testicle is derived from the testicular artery, originating off the aorta inferior to the ipsilateral renal artery. From here, it descends in the retroperitoneum with the gonadal vein, ultimately meeting with the vas deferens and exiting the retroperitoneum at the internal ring

(Fig. 64.20). The vasal artery is another source of blood supply for the testicle, arising from either the superior or inferior vesicle artery. The spermatic artery, a branch of the inferior epigastric artery, is the final arterial supply of the testicle. Near the tail of the epididymis, these three vessels coalesce to offer a variety of blood flow to the testicle.

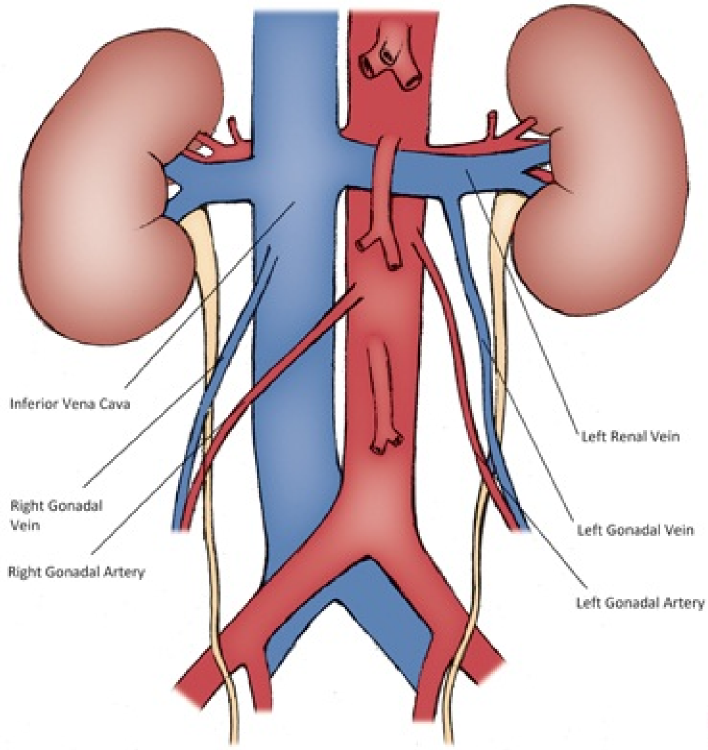

FIGURE 64.20 Arterial supply and venous drainage of the testicle.

The venous drainage of the skin of the scrotum is to the superficial external pudendal vein (see Fig. 64.15). Venous drainage of the testicle is via the pampiniform plexus, a collection of veins that coalesce to form the right or left gonadal vein. The right gonadal vein drains directly into the inferior vena cava, whereas the left gonadal vein drains to the left renal vein (see Fig. 64.20). Dilation of the pampiniform plexus may occur, resulting in a varicocele. Alternatively, compression or occlusion of the inferior vena cava may result in a more sudden onset varicocele concerning for a retroperitoneal cancer or caval thrombus from a renal tumor.

The lymphatics of the scrotum drain to the superficial inguinal lymph nodes. Unlike penile lymphatics, those of the scrotum do not tend to cross the raphe. The lymphatics of the testicles enter the retroperitoneum and drain to the periaortic and paracaval lymph nodes.

Innervation

The anterior scrotum is innervated by the anterior scrotal nerve, a division of the ilioinguinal nerve and the genital branch of the genitofemoral nerve. The posterior scrotum is supplied by the posterior scrotal nerve, a branch of the superficial perineal nerve. Like the blood supply, the nerves of the scrotum tend run parallel to the rugae and do not cross the raphe. Visceral innervation to the testicle arises from the renal and aortic plexus as well as the pelvic plexus. Nerves originating from the visceral and pelvic plexi travel with the gonadal vessels and vas deferens through the inguinal canal.

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CHAPTER 65 PARTIAL AND TOTAL PENECTOMY IN THE MANAGEMENT OF INVASIVE SQUAMOUS CELL CARCINOMA OF THE PENIS

FERNANDO P. SECIN, AGUSTÍN R. ROVEGNO, ANA MARÍA AUTRÁN GÓMEZ, AND RAFAEL SÁNCHEZ-SALAS

Penile cancer is an uncommon malignancy with specific geography-related incidence. Although high incidence rates account for up to 10% to 20% of all malignancies in developing continents, such as Asia, Africa, and South America, its incidence in Europe is low (one case per 100,000 people) (1). In the United States, it is estimated that 1,570 men will be diagnosed and 310 will die from this disease in 2013 (2).

There is an increasing body of literature supporting the association between sexually transmitted viral disease and penile cancer. Human papilloma viruses (HPV), especially types 16, 18, 31, and 33, are the most frequently detected types in penile cancer (3). In a large case series by Dillner et al. (4), HPV DNA was identified in penile neoplastic tissue. The authors found that in penile intraepithelial neoplasia, between 70% and 100% of the lesions were positive for HPV DNA, whereas invasive penile cancer was positive for HPV in only 40% to 50% of the cases (4).

However, the most important risk factor for invasive penile cancer is the presence of an intact foreskin. Penile cancer is rarely seen in Jews or in Igbos, an ethnic group of southeastern Nigeria, who ritually circumcise males on the eighth day of birth. The lowest incidence of penile cancer has been reported in Israeli Jews (0.1/100.000), making an argument in favor of the protective effect of circumcision (5). Schoen et al. (6) observed that the relative risk of invasive penile cancer for uncircumcised to circumcised men was 22:1. In a case-control study, neonatal circumcision was associated with a threefold decreased risk of cancer development, albeit 20% of penile cancer patients had been circumcised neonatally. When compared to men circumcised at birth, the risk for penile cancer was 3.2 times greater among those uncircumcised and 3.0 times greater on those circumcised after the neonatal period (7).

It appears that, enclosed preputial environment, associated with poor genital hygiene of the foreskin, chronic irritation, and exposure to certain etiologic agents, such as viruses, smegma, and hydrocarbons, may also play a causative role in the development of this tumor (8). A retrospective review of approximately 15,000 surgical specimens collected from the Igbos of Nigeria, over a period of 13 years, revealed four cases of penile carcinoma. One tumor arose at the glans penis. This localization pattern suggests that, in circumcised males, smegma-induced squamous carcinoma of the glans can be virtually abolished but not the ordinary squamous carcinoma that can develop by chance on the rest of the penis (9).

Other risk factors identified by case-control studies included chronic inflammatory conditions, such as balanoposthitis and lichen sclerosus, and PUVA treatment. PUVA is psoralen and ultraviolet A (UVA) photochemotherapy, traditionally used to treat psoriasis, vitiligo, atopic dermatitis, or alopecia areata. A consistent association was found between penile cancer and smoking, a dose-dependent association not explained by investigated confounding factors such as sexual history. Cervical cancer in the wife was not consistently associated with cancer of the penis in the husband (4).

Preventive measures that could be considered to reduce the risk of penile cancer include prevention of phimosis, local hygiene, treatment of chronic inflammatory conditions, limiting PUVA treatment, smoking cessation, and prevention of HPV infection (4).

Around 95% of penile cancers are squamous cell carcinoma (SCC) originating in the epithelium covering the glans, coronal sulcus, and/or foreskin. Several histologic subtypes have been described, each with distinctive clinicopathologic and outcome characteristics. The most common subtype is the SCC, representing 48% to 65% of penile carcinomas. Penile verruciform tumors encompass verrucous, warty (condylomatous), and papillary, not otherwise specified carcinomas. As a group, verruciform tumors are low-grade, with low metastatic and mortality rates. In contrast, basaloid and sarcomatoid carcinomas are among the most aggressive penile tumors. Other SCC variants, such as carcinoma cuniculatum and pseudohyperplastic, adenosquamous, and acantholytic carcinomas, are rare (10).

Penile cancer has a predictable natural history. In brief, it initially involves the glans in almost half of patients, followed by prepuce and/or penile shaft locations. Buck fascia and tunica albuginea penetration allows for infiltration of the corpus cavernosum, permeating the lymphatic system. Lymphatic spread is the rule. Tumor initially spreads to the superficial inguinal lymph nodes to continue into the deep inguinal and pelvic nodes. “Skip” lymphatic drainage is rare. If untreated, the inguinal metastases will enlarge, ulcerate through the skin (causing infection), or grow into the femoral vessels, producing potentially dangerous hemorrhage. Untreated patients with penile SCC usually die within 2 years of diagnosis due to uncontrollable locoregional growth or distant metastases. Hematologic metastases, spread to distant sites (e.g., lungs, liver, bone, and brain), are less common (1% to 10% in most large series) and usually occur late in the disease course. Distant metastases in the absence of regional node metastases are unusual (8).

Effective surgical intervention plays an essential role, in both the diagnosis and management of the primary disease, and is crucial for accurate staging and treatment of regional inguinal and pelvic lymph nodes. Goals of surgical treatment for the primary tumor are excision with adequate margins and preservation of as much functional penis as possible for upright voiding and erectile function (11).

Recent advances in the primary management of penile cancer have highlighted that penile-preserving approaches can be employed in select patients, whereby offering the potential of improved quality of life and erectile function preservation. Several clinical variables must be evaluated before considering penile-preserving approaches, including the primary tumor stage, grade, location of the lesion, and ability to maintain a “functional” penis. Complete tumor excision with negative surgical margins at the primary tumor site must never be compromised in order to eliminate the nidus for cancer dissemination as well as a potential site of local symptomatic recurrence. As we incorporate new surgical techniques to our armamentarium, we must ensure that cancer-specific outcomes of these approaches meet the established survival offered by the standard surgical treatment (12).

Delayed or incomplete surgical resections can have significant negative impact on patient survival, a situation made worse by the absence of effective systemic chemotherapy once metastatic disease occurs. Regional inguinal and pelvic lymph node dissection (PLND) remains an integral component of the treatment of invasive penile cancer with evidence mounting that a survival advantage exists for patients undergoing early prophylactic as opposed to therapeutic groin dissection (13). The management of lymph node involvement is described in Chapter 63.

DIAGNOSIS

The primary tumor may present as a nonhealing ulcer (Fig. 65.1), papule, indurated mass, or exophytic growth (Fig. 65.2). It may be associated with penile bleeding or purulent discharge. Physical examination of the primary penile lesion should evaluate and document the number of lesions, tumor dimensions (size), sites involved (foreskin, glans, shaft), color, morphology (flat, papillary, nodular, ulcerating, fungating), relationship with other structures (corpus spongiosum, corpora cavernosa, urethra), and boundaries (edges) (11) (Fig. 65.3).

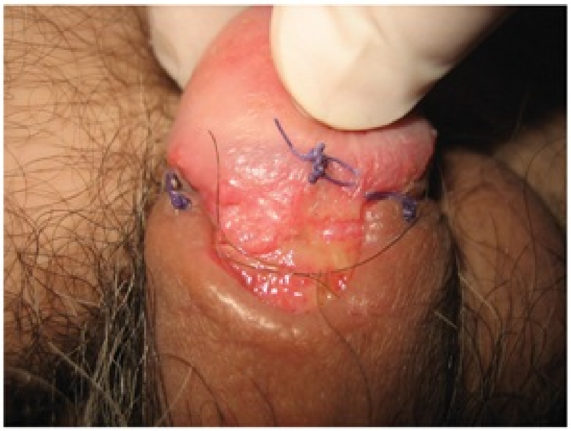

FIGURE 65.1 A nonhealing ulcer following circumcision.

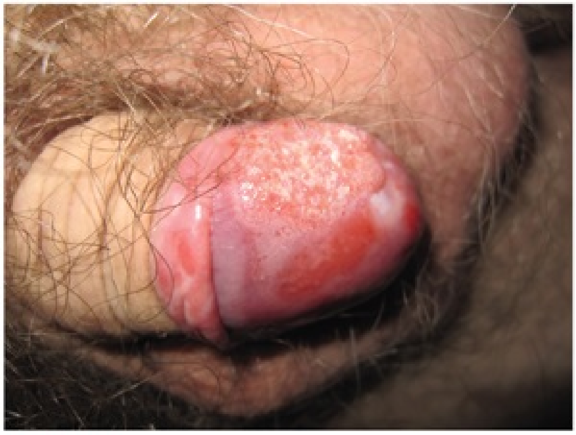

FIGURE 65.2 Erythematous elevated and indurated lesion in glans.

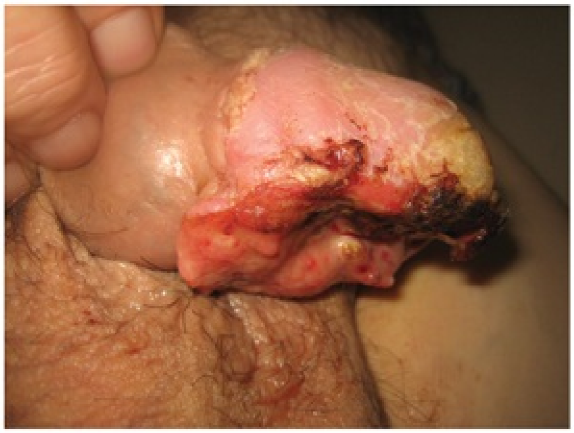

FIGURE 65.3 Ulcerated penile tumor compromising the urethra.

Clinical staging of the primary tumor can be incorrect in 26% of patients (Table 65.1). Understaging results from histologic infiltration not clinically evident and overstaging of absent infiltration may result from edema and infection (14).

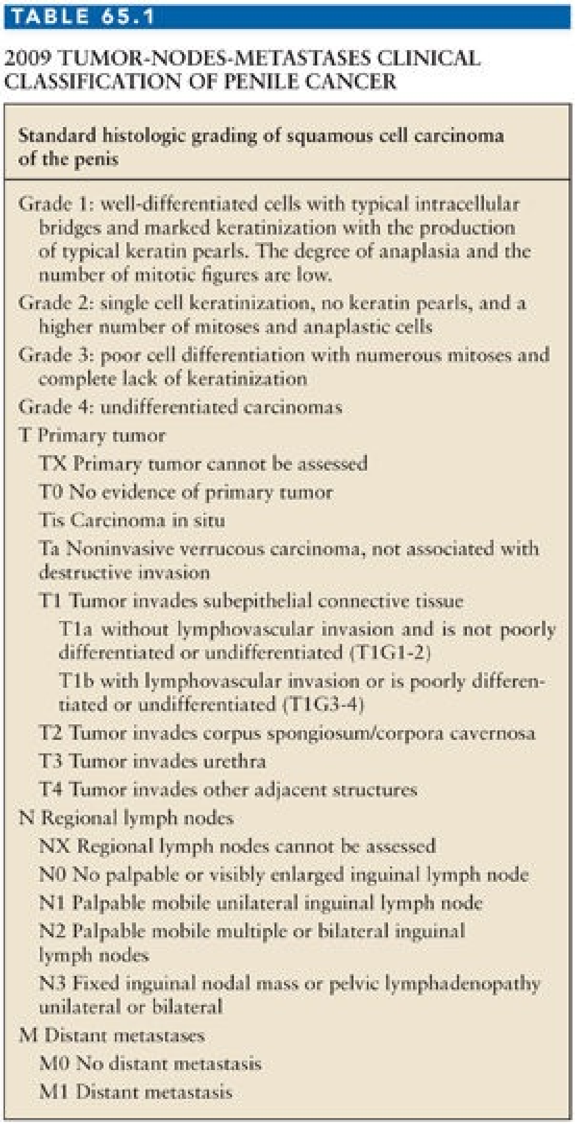

TABLE 65.1

2009 TUMOR-NODES-METASTASES CLINICAL CLASSIFICATION OF PENILE CANCER

Standard histologic grading of squamous cell carcinoma of the penis
Grade 1: well-differentiated cells with typical intracellular bridges and marked keratinization with the production of typical keratin pearls. The degree of anaplasia and the number of mitotic figures are low.
Grade 2: single cell keratinization, no keratin pearls, and a higher number of mitoses and anaplastic cells
Grade 3: poor cell differentiation with numerous mitoses and complete lack of keratinization
Grade 4: undifferentiated carcinomas
T Primary tumor
TX Primary tumor cannot be assessed
T0 No evidence of primary tumor
Tis Carcinoma in situ
Ta Noninvasive verrucous carcinoma, not associated with destructive invasion
T1 Tumor invades subepithelial connective tissue
T1a without lymphovascular invasion and is not poorly differentiated or undifferentiated (T1G1-2)
T1b with lymphovascular invasion or is poorly differentiated or undifferentiated (T1G3-4)
T2 Tumor invades corpus spongiosum/corpora cavernosa
T3 Tumor invades urethra
T4 Tumor invades other adjacent structures
N Regional lymph nodes
NX Regional lymph nodes cannot be assessed
N0 No palpable or visibly enlarged inguinal lymph node
N1 Palpable mobile unilateral inguinal lymph node
N2 Palpable mobile multiple or bilateral inguinal lymph nodes
N3 Fixed inguinal nodal mass or pelvic lymphadenopathy unilateral or bilateral
M Distant metastases
M0 No distant metastasis
M1 Distant metastasis

All penile lesions that appear suspicious for malignancy should undergo histologic evaluation, using one of the following methods: incisional biopsy, tissue core biopsy, fine needle aspiration cytology, brush biopsy, or excisional biopsy (14).

For small discrete lesions, the biopsy procedure can be, at the same time, diagnostic and therapeutic. The biopsy specimen, regardless of location, must contain adequate underlying tissue to allow the pathologist to determine the depth of tumor invasion, an important predictor of local tumor recurrence and regional nodal metastases (15,16).

Some lesions are considered premalignant in SCC of the penis. Lesions sporadically associated with SCC of the penis are cutaneous horns and bowenoid papulosis. Lesions at intermediate risk of developing SCC include lichen sclerosus/balanitis xerotica obliterans (Fig. 65.4). Up to one-third of penile erythroplasia of Queyrat or Bowen disease will transform to invasive SCC and are thus considered high risk of developing SCC of the penis (17).

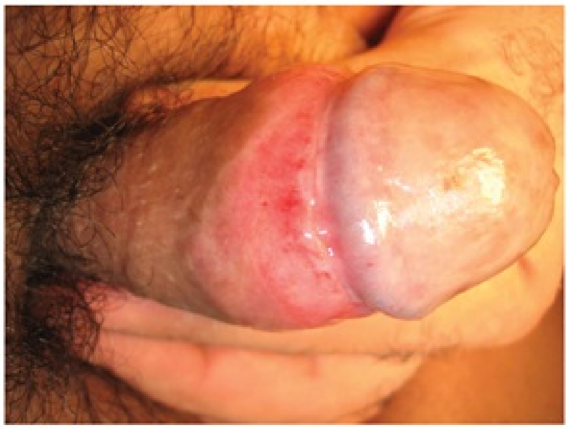

FIGURE 65.4 Balanitis xerotica obliterans, a premalignant condition.

For tumors involving only the prepuce, circumcision can be both diagnostic and therapeutic. Tumors involving the glans, glans and prepuce, coronal sulcus, or shaft are best approached with an initial excisional biopsy that includes ample underlying soft tissue to accurately determine the depth of invasion (11).

When deciding for a diagnostic biopsy only, an incision biopsy is the preferable option, taking a wedge of tissue that includes the tumor and adjacent normal tissue to improve histologic diagnosis. However, the histologic type and grade can be misinterpreted in 30%, the depth of invasion has been undetermined in 91%, and vascular invasion can be missed in 88% of cases (18).

Physical examination of the inguinal and pelvic areas to assess the lymph nodes is mandatory. Between 30% and 60% of patients presenting with SCC of the penis have enlarged lymph nodes in the groin (11). Ultrasound-guided fine needle aspiration cytology is indicated for both palpable and nonpalpable inguinal nodes because complete inguinal lymp node dissection (LND) is indicated in patients with regional node positivity (Fig. 65.5). Antibiotic treatment for 3 to 6 weeks before inguinal LND in patients with palpable inguinal nodes is recommended. Pelvic computerized tomography (CT) and magnetic resonance imaging (MRI) are not useful in patients with nonpalpable nodes. However, they are indicated in those with large, palpable inguinal nodes or in patients with confirmed inguinal lymph node metastasis (LNM) to detect iliac LNMs (Fig. 65.6). Abdominal CT and chest radiography or CT are advisable if the pelvic CT findings are positive to rule out distant metastasis (14,19) (Fig. 65.7). Positron emission tomography/CT is a promising method for detection of distant metastatic lesions and therapeutic strategy planning in penile cancer. However, few studies support its use possible due to its low incidence (20).

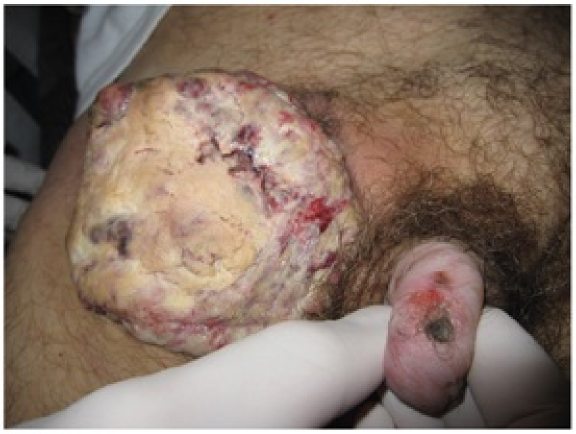

FIGURE 65.5 Ulcerated right inguinal nodes with a relatively small penile lesion.

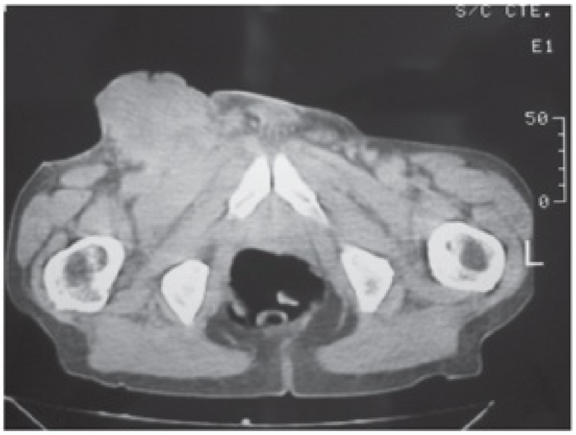

FIGURE 65.6 Pelvic CT to evaluate lymph node extension.

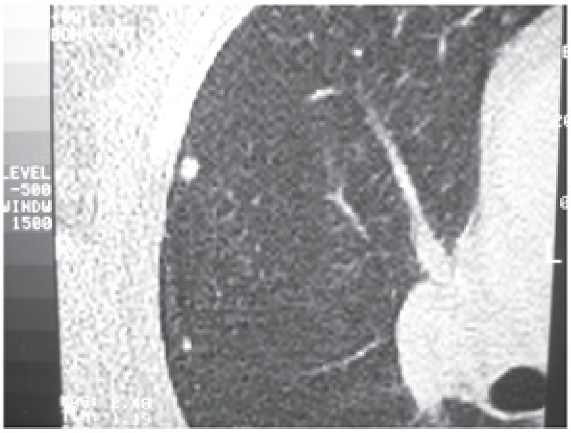

FIGURE 65.7 Chest CT scan show images consistent with lung metastasis.

A full discussion with the patient concerning the degree of penile resection required, the anticipated functional deficit, and the necessary reconstruction required is needed. Occasionally, plastic surgical consultation is requested if a wide local excision with complex rotational flap coverage is contemplated. If total penectomy is planned, a psychiatric consultation is recommended to be certain the patient has the emotional capacity to tolerate such a procedure (11).

The extent of the negative margin required is controversial in penile cancer. Although a 2-cm surgical margin has been traditionally proposed, more recent data suggest that for low-risk tumors a 1-cm clearance is adequate for grade 1 and 2 lesions, and 1.5 cm for grade 2 tumors (21). Nonetheless, experts recommend sending a frozen section of the proximal margin at the time of tumor resection to assure a microscopically negative margin (11).

Molecular markers are not of clinical use in SCC of the penis. SCC antigen is not sensitive in small tumor burden and has little prognostic significance for survival after surgery (22). Lymph node metastases are also correlated with the expression of p53, Ki-67, and E-cadherin, but these markers are not useful in clinical practice (23).

SURGICAL INDICATIONS (24,25)

Stage Ta-Tis

Treatment options for patients with Stage Ta-Tis penile cancer include 5% 5-fluorouracil (5-FU), 5% imiquimod cream; wide local excision including circumcision, cryotherapy, glansectomy, or laser treatment. The advantages of topical chemotherapy include simple application, low rates of toxicity, and adverse events. The disadvantages include risk of prolonged therapy (average duration of treatment of 4 to 6 weeks with estimated healing time of 4 to 8 weeks), local recurrence, and poor therapeutic efficacy in immunocompromised patients (26).

Laser therapy, either carbon dioxide (CO_2) or neodymium-yttrium-aluminum-garnet (Nd:YAG), has been successfully used as a first-line therapy for premalignant lesions and early stages of penile cancer since the 1980s. The CO_2 laser has a tissue penetration of 0.1 mm, whereas Nd:YAG laser penetrates to a depth of 4.2 mm. That is why laser is contraindicated in tumors with >6 mm depth invasion, T2 tumors and in patients not compliant to close follow-up due to its high recurrence rate (27).

The advantages of laser therapy include good functional and cosmetic outcomes and avoidance of surgery, assuming that oncologic outcome and survival are not affected by local recurrence. The disadvantages of laser therapy include its high recurrence rates, reported to be between 3.1% and 48%. The Nd:YAG laser can cause significant tissue coagulation and prevent accurate histologic diagnosis, resulting in understaging of the disease. Although the CO_2 laser does not cause significant tissue coagulation, it is limited by its lower tissue penetration compared with the Nd:YAG laser (28,29).

Cryotherapy is more commonly used in the treatment of genital warts and premalignant lesions than in penile cancer. A study comparing cryotherapy and topical 5-FU in the treatment of Bowen disease showed that the risk of recurrence after cryotherapy (13.4%) was greater than after 5-FU treatment (9%) (26,30).

Although cryotherapy and laser therapy can effectively treat selected patients with small superficial lesions, their effectiveness for overtly invasive penile cancers is uncertain and their use should not be considered an alternative to standard resection.

Stage T1G1-3 of the Foreskin

For patients with an invasive tumor confined to the prepuce, a penile-preserving strategy using circumcision is strongly recommended. Careful assessment of the glans is required to exclude dysplasia or carcinoma in situ. Alone, circumcision is curative for low-grade, low-stage preputial disease. The disadvantage of circumcision is the reported recurrence rate of 50% at 2 years, indicating the need for regular close surveillance (31).

Stage T1G1-3 of Glans

For patients with stage T1G1-3 of the glans, who can guarantee regular follow-up examinations, a penile-preserving strategy is strongly recommended. Choice of the treatment will be influenced by the size and location of the tumor and the possible side effects. Meticulous follow-up and/or self-examination are advisable in order to detect and rapidly treat local recurrence.

Treatment options include the following:

1. *Wide local excision* (*WLE*) with wide negative margins, with or without split or full-thickness skin graft, can be performed for precancerous lesions, discrete lesions, extensive preputial disease (where circumcision alone is not curative), and T1 low-grade tumors of the shaft. A 1- to 1.5-cm negative margin may adequate for low-risk tumors (21). Contraindications to WLE include tumor in close proximity to the urethra, urethral involvement, or lesions extending more than half of the glans penis. The disadvantages may include potential tumor recurrence and significant deformity or deviation of the penis during erections (32).

    Mohs micrographic surgery could be used with concurrent microscopic evaluation to ensure that a tumor-free plane is obtained. The indications for performing penile Mohs surgery are carcinoma in situ or verrucous carcinoma (which are of low to intermediate grade and have an exophytic growth pattern); lesions of the distal penis or glans penis, otherwise amenable to partial penectomy; and the desire for penile-preserving surgery in compliant patients. Higher than 85% 5-year survival rates have been reported with this procedure. The success rate is shown to be stage-dependent. The advantages of the Mohs technique include proper tumor mapping and excision of the tumor with no positive margins, and preservation of uninvolved penile tissue, with improved cosmetic or functional outcome. The disadvantage of the Mohs technique is its poorer local control as evidenced by the high rates (30%) of local recurrence after one procedure (33,34). However, most recurrences were suitable for further Mohs surgery. Contraindications to Mohs surgery include advanced tumor stage amenable to partial penectomy and, in instances where the involvement of the urethra, or the size of the defect, outweighs potential cosmetic or functional results. Complications, such as meatal stenosis or glans disfigurement, have been reported (26).
2. *Glansectomy* can be partial or complete. Recent studies have shown that a margin of 0.5 cm may be oncologically safe (35). Depending on the size of the defect, reconstruction can follow three techniques: (a) primary closure, (b) preputial or scrotal skin flap, or (c) skin grafting. Potential disadvantage of glansectomy is cancer recurrence in the remaining glans. Complications associated to reconstruction of the glans include loss, or graft contraction, graft overgrowth over the external urethral meatus, penile tethering by flaps, loss of penile length, and decreased penile sensitivity (36,37).
3. *Partial penectomy* remains the standard care for men with distal penile cancer and is particularly indicated when it is necessary to dissect the corpora cavernosa to achieve a negative margin. Extension into the urethra or corporal bodies and/or local recurrence of disease after previous conservative treatment are formal indications for partial penectomy. At least a 1-cm margin of resection is recommended (11). Leijte et al. (38) recently compared laser therapy, WLE, and radiotherapy to partial or total penectomy and showed that local disease recurrence rates were 5 to 6 times lower with the latter treatments, albeit there was no significant difference in overall disease survival (38). The presence of local recurrence after partial penectomy carries a poor prognosis. Partial penectomy offers excellent local control with low recurrence rates (<10%) and allows for preservation of urinary function and possible sexual function in most cases. The most common complication is neourethral meatal stenosis (39). Intraoperative frozen sections to achieve negative

surgical margins are always recommended in all aforementioned options.

Stage T2 of Glans

For patients with stage T2 disease of the glans, a conservative strategy of total glansectomy with or without resurfacing of the corporeal heads is recommended. An alternative treatment for very carefully selected patients is partial glansectomy of tumors involving less than 50% of the glans, provided close monitoring is possible. The traditional 2-cm macroscopic clear margin has been questioned by the international panel.

Stage T2 of Corpora and Stage T3

For patients with stage T2 or T3 disease, partial or radical amputation has been considered standard treatment. For lesions extending proximally, to a location that, partial penectomy would not achieve a functional penile remnant, total penectomy is advised (26).

Current guidelines also consider primary radiotherapy (external beam radiation therapy [EBRT]) as a treatment alternative in T1-2 N0 as penile-preserving strategy in highly selected patients. The National Comprehensive Cancer Network guidelines propose circumcision followed by either brachytherapy (BT) alone or EBRT with or without chemotherapy in patients with tumors less than 4 cm. The recommended radiation dose is 65 to 70 Gy with conventional fractionation, using appropriate bolus to primary penile lesion with 2-cm margins.

BT consists of implantation of a radioactive iridium (Ir 192) seed into the penis, and this is removed when the predetermined dose has been delivered. Circumcision should be performed before radiotherapy with glans tumor to reduce radiation-induced complications. BT offers good success rates particularly for low-stage disease and in general is more successful than EBRT. The 5-year rate of penile preservation after BT ranges from 70% to 88%, which is higher than the corresponding 36% to 66% rates for EBRT (26,40).

When opting for radiotherapy for tumors larger than 4 cm, circumcision is followed by EBRT with chemotherapy. In this case, 45 to 50.4 Gy are administered to a portion of or whole penile shaft, depending on the extent of the lesion, plus pelvis/inguinal nodes administration. This is followed by a boost on the primary lesion, with a 2-cm margin, for a total dose of 60 to 70 Gy. BT should be used very selectively in larger tumors and be also restricted to patients compliant to close follow-up.

In T3-4 patients or N-positive patients not suitable for surgical treatment, 45 to 50.4 Gy are administered to the whole penile shaft, pelvic lymph nodes, and bilateral inguinal lymph nodes, to then boost the primary lesion, with a 2-cm margin, and gross lymph nodes, for a total dose of 60 to 70 Gy.

The preferred radiosensitizing agent is cisplatin alone or in combination with 5-FU. Paclitaxel, ifosfamide, and cisplatin (TIP) is the first-line combination chemotherapy of choice. 5-FU in combination with cisplatin can be considered as an alternative to TIP (25).

The advantages for radiotherapy include good long-term cosmesis and excellent rate of penile preservation. However, local failure rates after radiotherapy are higher than after partial penectomy. Most frequently reported complications are urethral stenosis, 10% to 45% at 3 years; glans necrosis or ulceration, 10% to 20% at 7 and 18 months after treatment, requiring debridement or amputation of penile tissue; and late fibrosis of the corpora (41). Skin pigmentation, telangiectasia, long treatment duration, and healing time (up to 3 months) are other disadvantages of radiotherapy (40,42,43).

No scientifically supported recommendations can be given regarding surgical procedures versus radiotherapy. Institutional experience and possibilities play an important role in decision making (17).

SURGICAL TECHNIQUE

Partial Penectomy

The operation should be designed, if possible, to allow the patient to void in the upright position and without the need to push away the scrotum; otherwise, a perineal urethrostomy should be considered. After proper anesthesia, the patient is placed in supine position. The lesion and urine should be cultured preoperatively and appropriate parenteral antibiotics started prior to the surgical procedure (Fig. 65.8). The penis is prepared with a povidone-iodine solution, and the tumor isolated using a sterile condom or glove that is sutured in place using 3-0 silk sutures to avoid spillage of cells during penile manipulation. It is recommended to outline the planned incision with a marking pen, providing an adequate minimum 1-cm margin (Fig. 65.9). A tourniquet is placed around the base of the penis to minimize blood loss, especially during sectioning of the cavernous bodies (Fig. 65.10). The incision is circumferentially carried through the skin, dartos (superficial fascia), and Buck fascia (deep fascia) to the tunica albuginea. On the dorsum of the penis, the dorsal neurovascular bundle is individually ligated and sectioned with absorbable sutures (see Fig. 65.10). As the resection is carried ventrally, a 1-cm stump of the urethra is created (Fig. 65.11). The corpora cavernosa are sharply divided down to the urethra and the central cavernosal arteries ligated on each side (Figs. 65.12 and 65.13). The corporal ends are closed with 2-0 absorbable sutures, incorporating Buck fascia and tunica albuginea (Fig. 65.14). The penile base tourniquet is then released, and all minor vessels are fulgurated or ligated until adequate hemostasis is obtained. The urethra is spatulated to prevent stenosis of the neomeatus (Fig. 65.15) and sutured to the ventral penile skin (Fig. 65.16). A 16Fr Foley catheter is left indwelling for 48 hours (11).

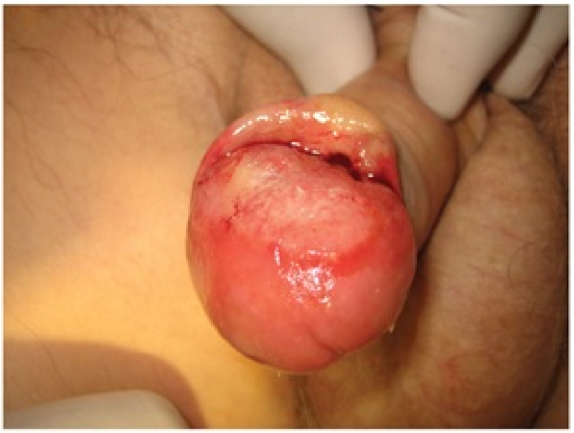

FIGURE 65.8 Ulcerated lesion of the glans and sulcus requiring partial penectomy.

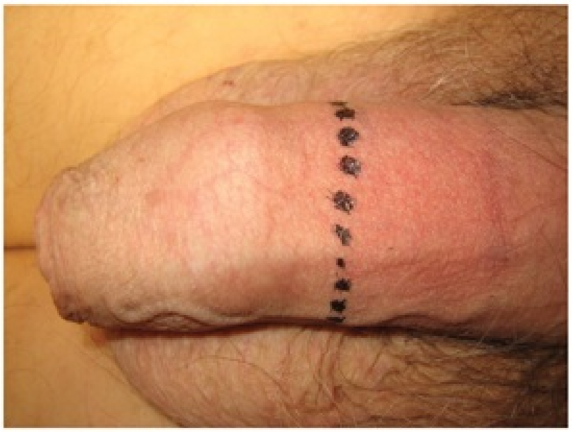

FIGURE 65.9 The incision is outlined with a marking pen, providing an adequate minimum 1-cm margin.

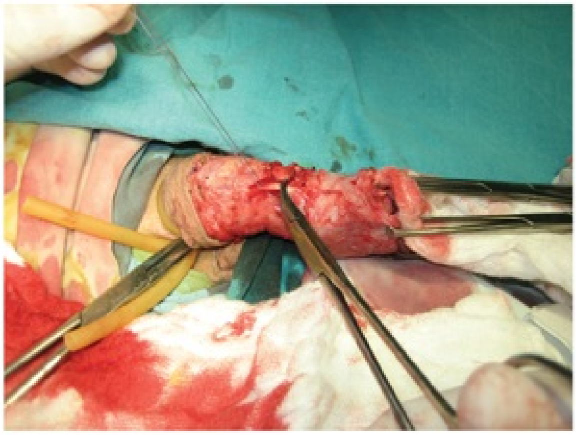

FIGURE 65.10 On the dorsum of the penis, the dorsal veins are individually ligated. Note the tourniquet at the base of the penis using a rubber catheter.

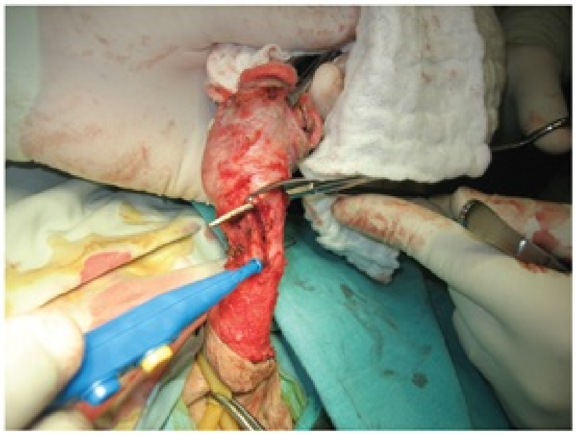

FIGURE 65.11 Creation of a 1-cm urethral stump.

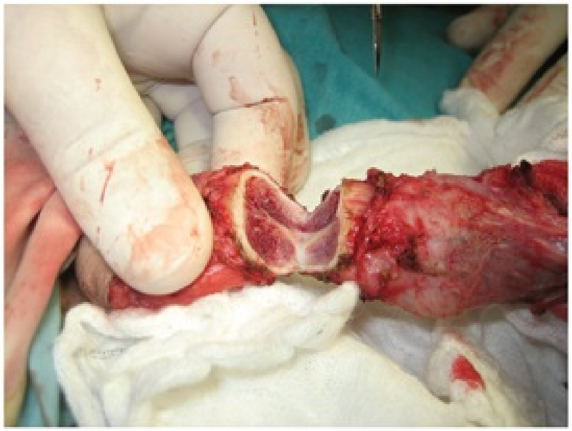

FIGURE 65.12 The corpora cavernosa are sharply divided.

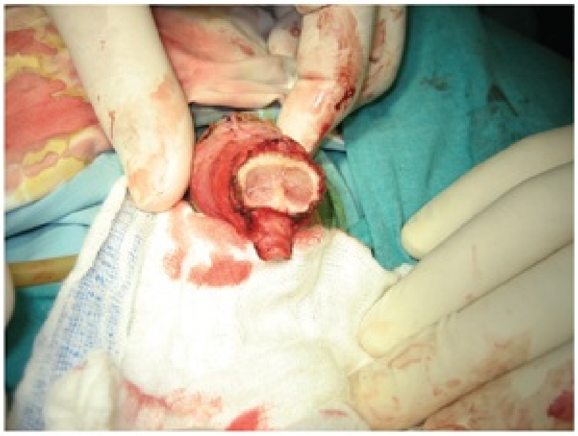

FIGURE 65.13 Cavernous bodies do not bleed due to the tourniquet. Note the 1-cm urethral stump.

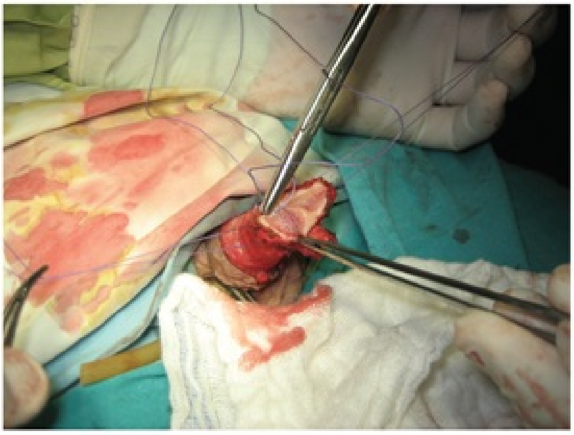

FIGURE 65.14 The corporal ends are closed with 2-0 absorbable sutures.

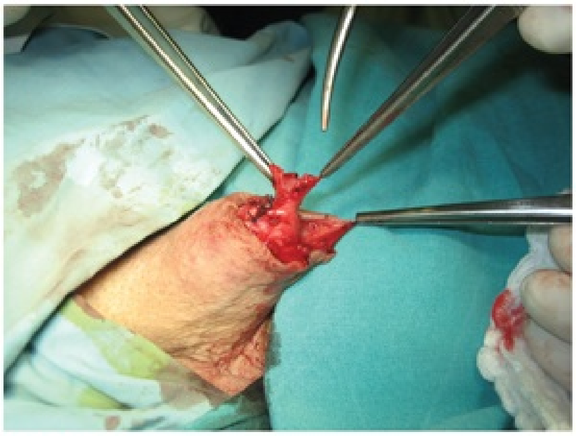

FIGURE 65.15 The urethra is spatulated to prevent stenosis of the neourethra.

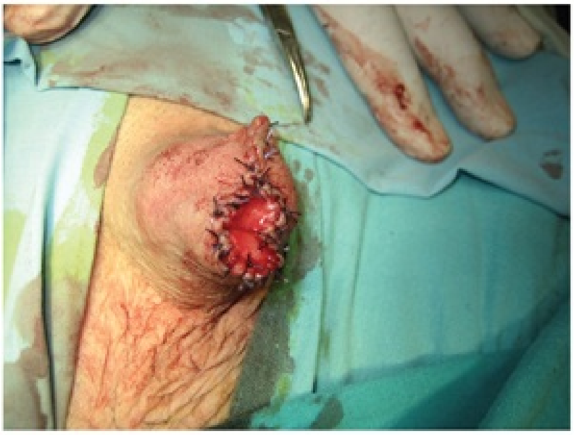

FIGURE 65.16 The urethra is sutured to the ventral penile skin.

Total Penectomy

Total penectomy is indicated for proximal tumors that are locally advanced and sometimes associated with painful local symptoms. Contrary to partial penectomy, the patient is placed in low lithotomy position. The lesion is prepared and covered in a similar fashion to the partial penile resection. Again, antibiotics are tailored to preoperative urine and penile tumor cultures. During total penectomy, an incision is carried out circumferentially at the base of the penis with extension into the median raphe of the scrotum (Fig. 65.17). The suspensory ligament of the penis is identified and divided at the base of the penis. The dorsal vein and penile arteries are ligated and divided. The penis is then reflected cephalad, the Buck fascia is opened ventrally (see Fig. 65.17), and the urethra is dissected free from the corpora cavernosa (Fig. 65.18). The urethra and corpus spongiosum are mobilized from the corpora between clamps and divided (Fig. 65.19). At the distal bulbar region, the urethra is divided, preserving enough length for construction of a perineal urethrostomy. The urethral remnant is passed through the scrotum to the midline perineum and the urethrostomy is performed. The corpora cavernosa are dissected up to the ischiopubic rami, clamped, sectioned, and sutured (11) (Figs. 65.20 and 65.21).

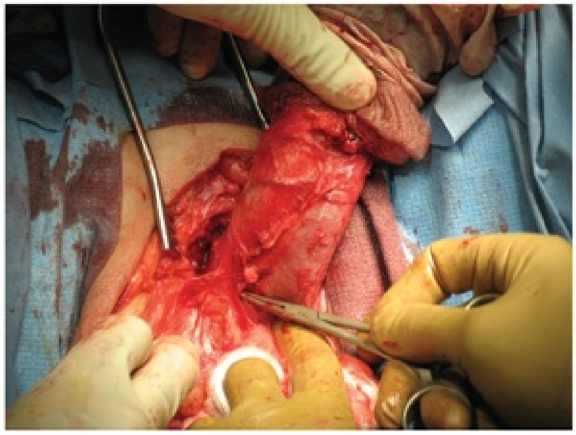

FIGURE 65.17 The penis is then reflected cephalad, the Buck fascia is opened ventrally. Note the extent of the incision.

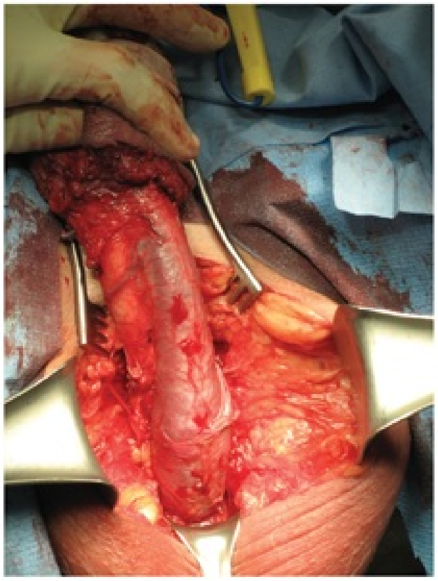

FIGURE 65.18 The urethra is dissected free from the corpora cavernosa. Again, note the extent of the incision.

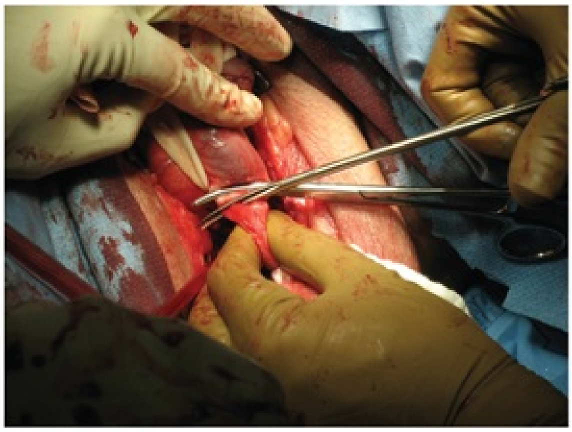

FIGURE 65.19 The urethra and corpora spongiosum are mobilized from the corpora between clamps and divided.

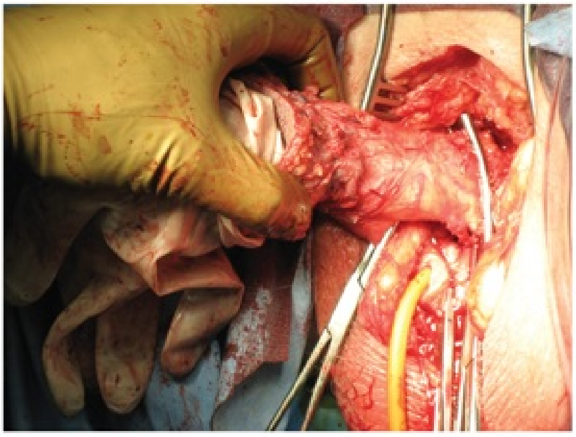

FIGURE 65.20 The corpora cavernosa are dissected up to the ischiopubic rami, clamped, and sectioned.

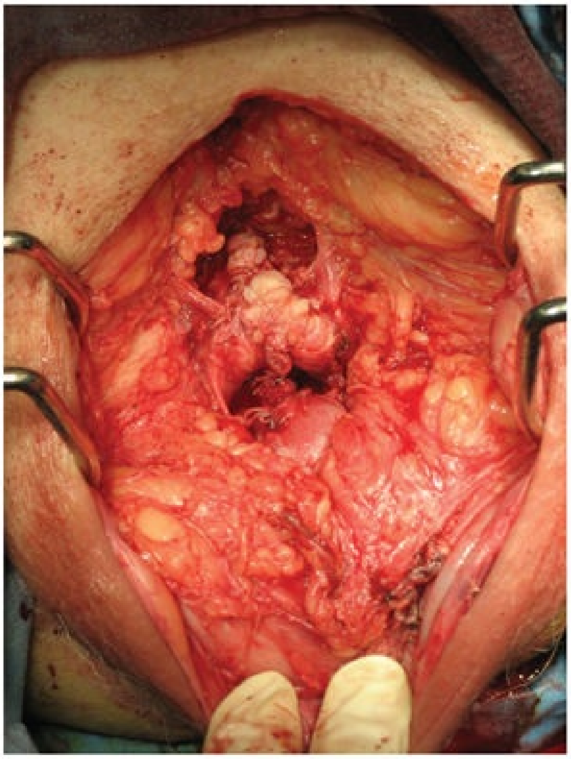

FIGURE 65.21 The corpora cavernosa are sutured.

The perineal urethrostomy is constructed by removing a 1-cm ellipse of skin and subcutaneous tissues from the midperineum, equidistant from the anus and scrotum (Fig. 65.22). Urethral angulations are to be avoided when the urethra is drawn into the perineal incision. The urethra is then spatulated dorsally, and a V-inlay of skin can be created and sutured watertight to the urethra using 3-0 absorbable sutures. An 18Fr Foley catheter is inserted, and drains are left to drain each side of the scrotum. The scrotal incision is closed transversally to allow elevation of the scrotum away from the perineal urethrostomy using 3-0 absorbable sutures (Fig. 65.23). The Foley catheter is left indwelling for at least 5 days and drains removed within 48 hours (11) (Fig. 65.24).

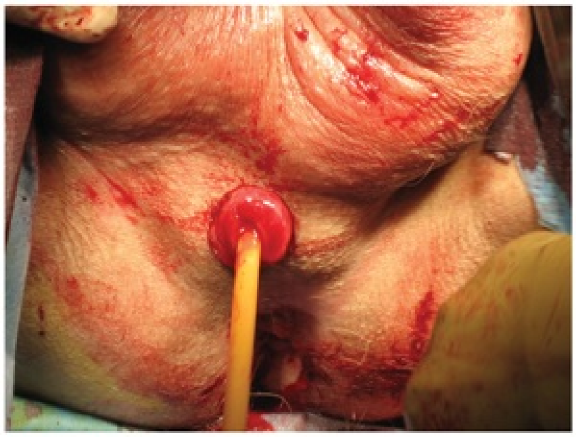

FIGURE 65.22 Construction of the perineal urethrostomy equidistant from the anus and scrotum.

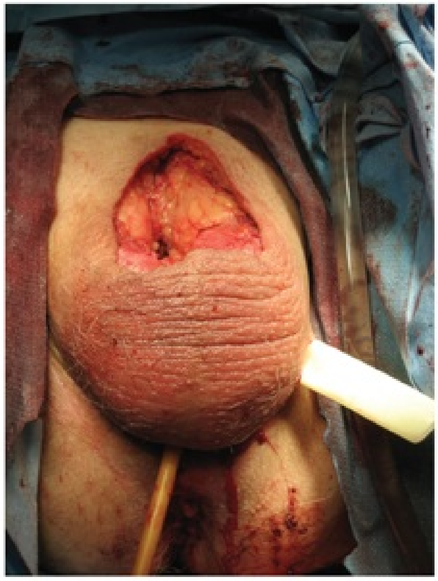

FIGURE 65.23 The scrotal incision will be closed transversally to allow elevation of the scrotum away from the perineal urethrostomy.

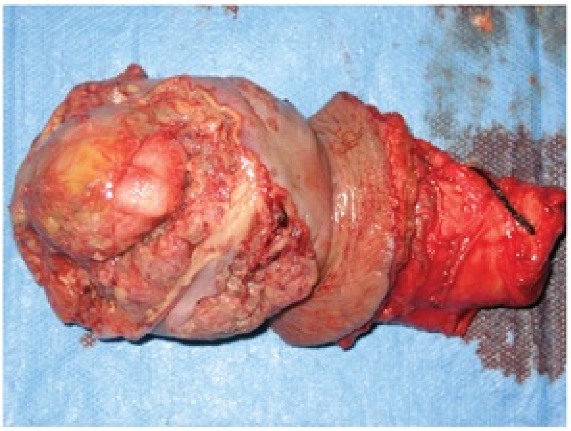

FIGURE 65.24 Resected specimen.

In rare cases, the site of attachment of the corpus cavernosum to the pubic bone may need to be resected in order to achieve a clear margin. Additionally, lesions involving the perineum and anterior abdominal wall may need total emasculation, and the defect covered with a myocutaneous flap (44). Total phallic reconstruction after total penectomy is an option for motivated patients after a psychological evaluation and proper counseling, for it carries a high rate of complications (24,25).

POSTOPERATIVE MANAGEMENT AND COMPLICATIONS

Early complications after partial or total penectomy include wound infection, hematoma, and stricture of the neomeatus. The most common complication of partial and total penectomy is meatal stenosis (Fig. 65.25). The V-inlay technique has been used to decrease the stenosis at the urethral opening. Adequate irrigation of the urethral stump at the time of neomeatus reconstruction is key to avoid ischemic complications. Stricture of the neomeatus can be managed by simple (self) dilatation or meatotomy, whereas recurrent strictures may need some form of meatoplasty.

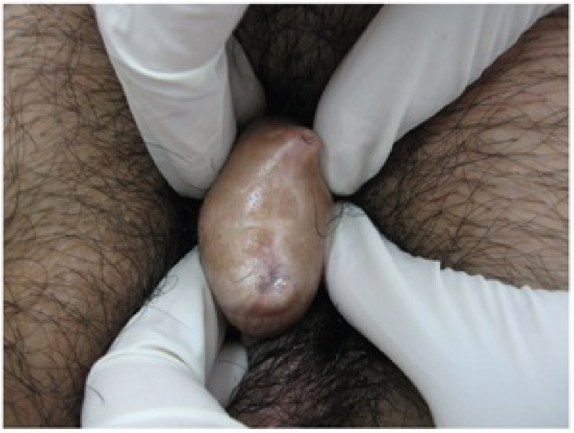

FIGURE 65.25 Meatal stenosis after partial penectomy. Purulent discharge is noted.

As mentioned earlier, patients with partial and total penectomy suffer psychological and physical trauma that can adversely affect their quality of life; however, there is little published on this subject. For previously potent men, erectile function is usually preserved and a normal sense of orgasm and ejaculation can persist after partial penectomy. Patients with total penectomy can sometimes reach orgasm if the sensitive areas around the scrotum are stimulated (11,39).

MANAGEMENT OF REGIONAL LYMPH NODES

General Considerations

The single most important prognostic factor for cancer-specific survival is the presence of nodal metastases (46). Nevertheless, patients with a low number of positive nodes can still be cured with an adequate surgical approach (47). In pN1 (intranodal metastasis in a single inguinal lymph node) patients with surgically resected inguinal lymph nodes, 5-year survival rates are around 62% (48).

Like all SCCs, penile cancer has a propensity for locoregional dissemination, whereas hematogenous dissemination in the absence of lymphatic invasion is very uncommon. Metastases in penile carcinoma occur in a sequential manner, with tumor cells embolizing through first-echelon superficial regional inguinal nodes and then on to second-echelon deep pelvic nodes (11).

The statistical probability of inguinal micrometastases can be estimated using risk group stratification or a risk calculation nomogram (19). However, patients with no evidence of tumor on preoperative physical examination, ultrasound or fine needle aspiration cytology are estimated to have an approximately 20% chance of harboring occult metastases, and unfortunately, contemporary imaging with CT scan or MRI are not able to reliably detect minimal metastatic disease (11,49). Therefore, early detection and treatment of metastases may be of great importance in selected patients.

Founded on original studies by Ramón Cabañas (50) at Memorial Sloan Kettering Cancer Center, the detection of these metastases in patients with cN0 disease has changed in the last 20 years since the introduction of dynamic sentinel node biopsy (DSNB) for cN0 cases (51). This evolving technique has the potential to identify early metastatic disease and at the same time spare the side effects of groin dissection in patients who are node-negative. Unlike other genitourinary tumors (renal, upper tract urothelial), in which nodal involvement is often synonymous with incurable disease, nodal metastases in penile cancer are potentially curable, even in patients with locally advanced lymphatic involvement (11).

The management of cN0 cases has shifted from observation to risk adapted inguinal LND and DSNB instead of prophylactic inguinal LND (52).

Since DSNB introduction in 1994, improvement of cancer-specific survival has been observed in cN0 cases of SCC of the penis after adjusting for pathologic T stage and grade, with the most probable reason being the introduction of DSNB and early treatment of microscopic disease (48). However, the probability of false-negative results underlines a strict follow-up scheme in node-negative patients after DSNB. Patients who cannot comply with a strict follow-up should not be submitted to DSNB.

According to the recommendations formulated and discussed at the first International Consultation on Penile Cancer, ultrasound-guided fine needle aspiration cytology is indicated for both palpable and nonpalpable inguinal nodes. If the findings confirm LNM, complete inguinal LND is indicated in the absence of distant spread. In patients with nonpalpable inguinal nodes, if the ultrasound-guided fine needle aspiration cytology findings are negative for tumor, DSNB with lymphoscintigraphic and blue dye localization can be performed if the equipment and technical expertise are available (19) (Figs. 65.26 to 65.28). In the absence of DSNB expertise, sentinel node biopsy based on the anatomic position can be performed, provided the patient is willing to accept the potential false-negative rate of 25% (50).

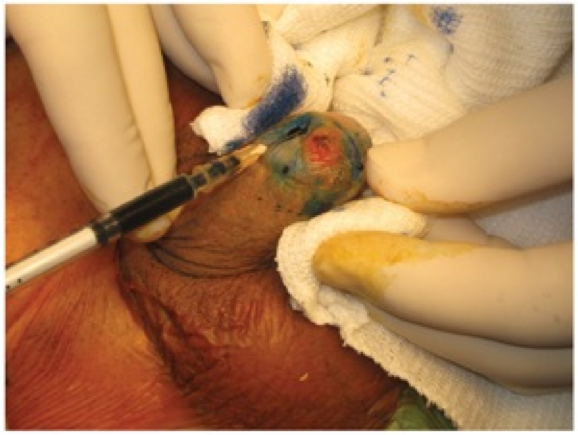

FIGURE 65.26 Perilesional injection of blue dye during DSNB.

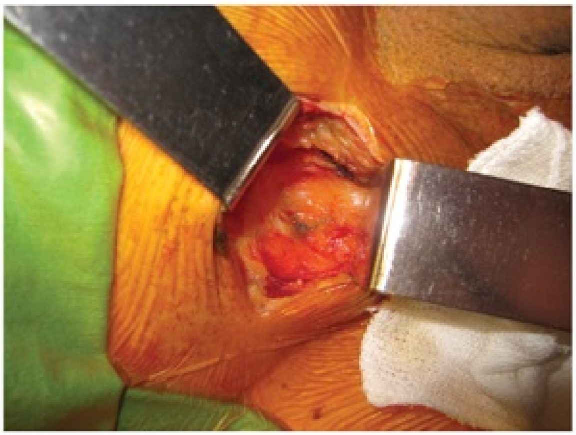

FIGURE 65.27 Tracing of blue dye into first echelon right groin lymphatics.

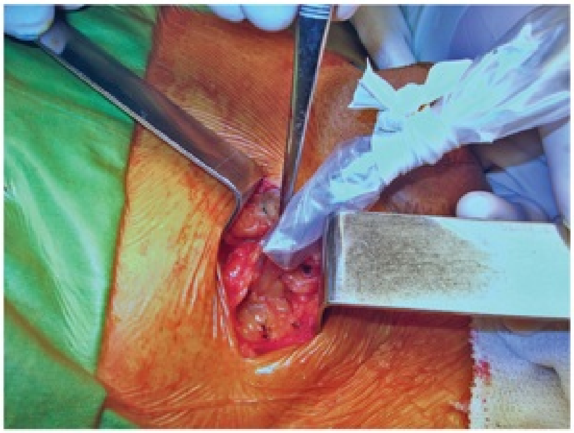

FIGURE 65.28 Lymphoscintigraphic (portable gamma probe) and blue dye localization of sentinel node during DSNB.

DSNB is usually performed at the time of the penile tumor removal. Frozen section histologic examination can be used during sentinel node biopsy or limited inguinal LND. If the results are positive, complete inguinal LND can be performed immediately. Although some surgeons advocate inguinal LND at the time of penectomy, others advocate avoiding immediate groin dissection wishing not to inflict its potential morbidity (cellulitis, flap necrosis, lymph edema) without the certainty of a therapeutic effect (19).

In patients with cytologically or histologically proven inguinal metastases, complete inguinal LND should be performed ipsilaterally. Because there is a 60% rate of bilateral disease because of the rich lymphatic communications at the base of the penis, patients with histologically confirmed inguinal metastases involving two or more nodes on one side, contralateral limited inguinal LND is recommended. Frozen-section analysis can be performed, with complete inguinal LND if the frozen-section analysis findings are positive (19).

PLND is recommended if two or more proven inguinal metastases, grade 3 tumor in the lymph nodes, extranodal extension, or large (2 to 4 cm) inguinal nodes are present, or if the femoral (Cloquet) node is involved. Performing inguinal LND before PLND is preferable because PLND can be avoided in patients with minimal inguinal metastases, thus avoiding the greater risk of chronic lymphedema (19). It is very unusual for metastatic cells to skip inguinal nodes into pelvic or other node stages (11).

The statistical probability of inguinal micrometastases can also be estimated using risk group stratification or a risk calculation nomogram. Surveillance is recommended if the nomogram probability of positive nodes is <10%. Surveillance is also recommended if the primary lesion is grade 1, pTis, pTa (verrucous carcinoma), or pT1, with no lymphovascular invasion, and clinically nonpalpable inguinal nodes, but only provided the patient is willing to comply with regular follow-up. In the presence of factors that impede reliable surveillance (social reasons, obesity, previous inguinal surgery, or radiotherapy) prophylactic inguinal LND might be a preferable option.

In the intermediate-risk group (nomogram probability 10% to 50%, primary tumor grade 1-2, T1-T2, cN0, no lymphovascular invasion), surveillance is acceptable, provided the patient is informed of the risks and is willing and able to comply. If not, DSNB or limited (modified) inguinal LND should be performed.

In the high-risk group (nomogram probability >50% or primary tumor grade 2-3 or T2-T4 or cN1-N2, or with lymphovascular invasion), bilateral inguinal LND should be performed (13).

The fact that there are no curative chemotherapy regimens currently available for the treatment of disseminated disease enhances the appeal of a preemptive surgical approach to patients at risk for metastatic penile cancer. Although the argument for early groin dissection is based on a relatively limited number of patients from retrospective studies, it makes intuitive sense that the early intervention of minimal metastatic disease would lead to an improved probability of survival.

Patients with grossly enlarged iliac nodes in CT or MRI, or patients with fixed or recurrent inguinal nodes are candidates for neoadjuvant chemotherapy and the response assessed before proceeding with pelvic and/or inguinal LND (17,19).

Inguinal Lymph Node Dissection Technique

As described by Dr. Willet Whitmore at Memorial Sloan Kettering Cancer Center, the inguinal LND is characterized by generation of thick skin flaps to reduce the perioperative morbidity of leg lymphedema (11).

The blood supply to the skin of the inguinal region derives from branches of the common femoral artery—the superficial external pudendal, superficial circumflex iliac, and superficial epigastric arteries. Complete inguinal dissection necessitates ligation of these branches. Viability of the skin flaps raised during the dissection depends on anastomotic vessels in the superficial fatty layer of Camper fascia that course lateral to medial along the natural skin lines. Because lymphatic drainage of the penis to the groin runs beneath Camper fascia, this layer can be preserved and left attached to the overlying skin when the superior and inferior skin flaps are fashioned. On the basis of this anatomy, a transverse skin incision least compromises this blood supply, and skin flaps are developed in the plane just beneath Scarpa fascia.

The patient is positioned supine in the frog leg position. Although a variety of incisions have been described, an oblique incision is made three fingerbreadths below the inguinal ligament (Fig. 65.29). As mentioned, thick skin flaps are developed. The boundaries of the dissection are superiorly, the inguinal ligament; laterally, the Sartorius muscle; inferiorly, the base of the femoral triangle; and medially, to the adductor longus muscle (Fig. 65.30). The saphenous vein is identified at the base of the femoral triangle, ligated, and divided. Small branches of the femoral artery and vein as well as lymphatic vessels are meticulously tied and clipped as the dissection proceeds toward the saphenofemoral junction and the fossa ovalis. The undersurface of the inguinal ligament is dissected. There is no need to dissect beneath the femoral vessels because all nodal tissue rests above. The node package is usually delivered when the saphenous vein is ligated as it enters the femoral vein. The Sartorius muscle is sharply divided from its attachment at the anterior iliac spine, mobilized on its fascial pedicle, rotated and sutured to Cooper ligament in order to cover the femoral vessels. Closed suction drain is placed above the Sartorius muscle and brought out through a separate stab wound. Compression stockings and/or intermittent pneumatic compression devices are routinely used in the perioperative period. Early ambulation with strict orders to avoid the sitting position is recommended

(11).

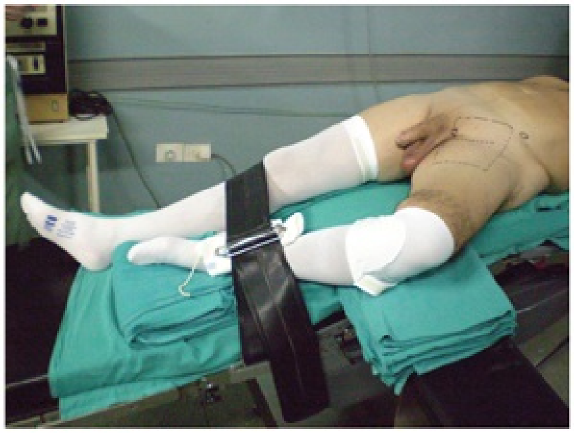

FIGURE 65.29 The patient is positioned supine in the frog leg position with compressive stockings. A curved transverse incision is made three fingerbreadths below the inguinal ligament.

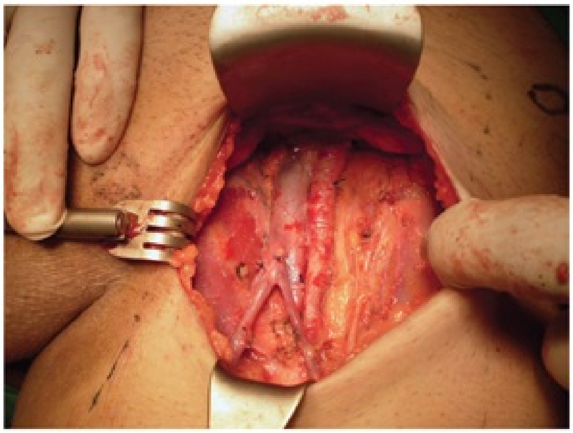

FIGURE 65.30 The boundaries of the dissection are superiorly, the inguinal ligament; laterally, the sartorius muscle; and inferiorly, the base of the femoral triangle and medially, to the adductor longus muscle. In this case, the saphenous vein was preserved.

Catalona (53) has described a modified groin dissection with a shorter skin incision, with the aim of decreasing postoperative complications in patients with clinically negative inguinal lymph nodes. The author originally described the technique in six patients, in whom the lateral and caudal extents of nodal excision were reduced, and the saphenous veins preserved. Nine years later, a follow-up study of the technique in a total of nine patients was presented, with none of them having disease recurrence despite three of them had positive nodes. Two patients developed skin flap necrosis, one had prolonged lymphatic drainage, and one a delayed groin lymphocele and cellulitis (54). Some authors have questioned the reliability of this technique, on the grounds that understaging may occur. Lopes et al. (55) reported two inguinal lymph nodes recurrences within the operative field in 13 patients with clinically negative inguinal nodes who underwent the modified technique.

Therefore, the lymph node packet can be analyzed by frozen section, and if it confirms metastatic disease, then a complete inguinal lymphadenectomy can be performed. A single photon emission CT study has shown that all sentinel nodes were located in the superior and central inguinal zones, with most found in the medial superior zone. No lymphatic drainage was observed from the penis to the two inferior regions of the groin, and no direct drainage to the pelvic nodes was visualized (56). With the advent of DSNB, the future of this modified groin dissection seems to be limited to centers without such technology (11).

There is a high incidence of complications after inguinal LND. The most common complications are wound infection (10% to 20%), skin necrosis with or without wound dehiscence (14% to 65%), lymphocele/seroma (19% to 45%), and lymph edema (2% to 100%) (Fig. 65.31). That is why wound should be closely monitored with early therapeutic antibiotics prescribed in case of wound cellulitis (11).

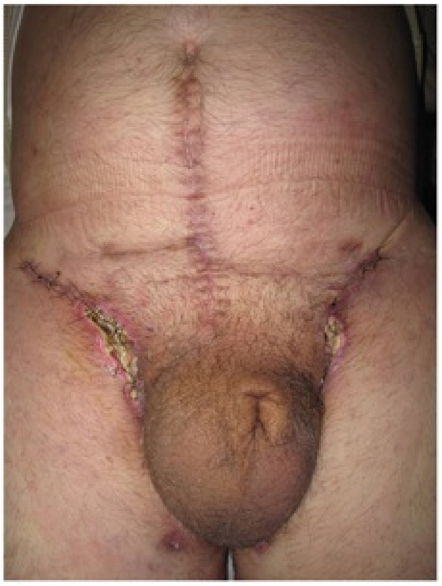

FIGURE 65.31 Wound dehiscence and infection in a patient with simultaneous bilateral inguinal LND.

With the objective of decreasing cumbersome complications, different centers started to develop a minimally invasive inguinal LND (57–59). Mathevet et al. (60) have presented an interesting experience with a gasless endoscopic approach for the inguinal dissection in vulvar and distal vaginal carcinoma. This is probably the most extensive experience for the inguinal endoscopic approach, and they reported low morbidity outcomes with a single operative vascular lesion. They verified 25% of perioperative complications, represented by lymphoceles observed in seven patients.

In the urologic field, Bishoff et al. (61) presented the initial experience with inguinal endoscopic dissection for penile carcinoma; they described a subcutaneous modified inguinal lymphadenectomy in two cadaveric models and one patient with stage T3N1M0 penile carcinoma. This initial experience was not completed due to the presence of a large lymph node that precluded the dissection.

Tobias-Machado et al. (62) reported a clinical experience with their video endoscopic inguinal lymphadenectomy (VEIL) technique in 10 patients with clinically negative inguinal nodes. Based on risk factors for lymph node metastasis, the authors performed the standard open surgery in one groin and a video-assisted surgery in the contralateral side. Despite the small number of patients, the authors noted a significant decrease in cutaneous complications and overall morbidity with VEIL. The mean number of retrieved and positive lymph nodes was similar for the two techniques. At a mean follow-up of 18.7 months, no signs of recurrence or disease progression were noted (62).

One year later, Sotelo et al. (58) described a standardized technique of endoscopic groin dissection for penile carcinoma with a preoperative Doppler ultrasound mapping of the inguinal region (60). More recently, Josephson et al. (63) reported a robotic-assisted endoscopic inguinal LND in a 37-year-old patient with palpable inguinal nodes despite oral antibiotics, arguing how robotic technology potentially allowed for an ergonomic platform and dexterity.

Matin et al. (64) prospectively determined the oncologic adequacy of robotic assisted VEIL by having an independent surgeon perform a separate open incision at the conclusion of the robotic assisted VEIL in 19 groins. The verifying surgeon confirmed that 18 of 19 inguinal fields had an adequate inguinal LND.

In summary, minimally invasive inguinal LND seems to be less morbid and early oncologic results are encouraging. However, clinical experience is still limited (65).

FOLLOW-UP

Recommendations for follow-up are tailored to primary tumor and lymph node status characteristics. Patients with penile-preserving treatment are recommended to be followed every 3 months for the first 2 years and every 6 months until year 5, with regular physician or self-examination. This frequency decreases to every 6 months during the first 2 years and yearly up to year 5 in patients with penile amputation.

Patients whose inguinal lymph nodes were observed or those whose nodes were positive are recommended to be followed every 3 months for the first 2 years and every 6 months until year 5 with regular physician or self-examination and groin ultrasound with fine needle aspiration biopsy. In those with pN0, the follow-up frequency decreases to every 6 months during the first 2 years, and yearly up to year 5, again, with regular physician or self-examination and groin ultrasound with fine needle aspiration biopsy (17).

CONCLUSIONS

Risk factors for penile cancer are known, and prophylactic measures should be taken. Early surgery is essential in the diagnosis and treatment of the penile lesion and the management of the inguinal and/or pelvic nodes. Effective local control of carcinoma in situ or Ta tumors can be achieved by excision, local ablation therapies, and Mohs microsurgery. As the T stage increases, surgical resection with circumcision, partial penectomy, or total penectomy plays an increasingly important role in the management of penile cancer. Regional lymph nodes can be enlarged because of inflammation or early metastatic disease. Lymphadenectomy is an integral part of the management of penile cancer because early dissection of involved lymph nodes improves survival. Therefore, a strong argument for aggressive diagnosis with aspiration cytology, DSNB, or prophylactic groin dissection can be made for patients with high-grade invasive primary tumors as opposed to the protracted administration of antibiotics and surveillance approach. Careful follow-up is necessary and should be tailed to patient and tumor characteristics. For patients with bulky groin metastases, neoadjuvant chemotherapy might be playing an increasing role. Surgical intervention plays no role in the treatment of distant metastases from penile cancer.

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CHAPTER 66 ■ INGUINAL LYMPHADENECTOMY FOR PENILE CARCINOMA

JACK W. LAMBERT AND MICHAEL B. WILLIAMS

Penile carcinoma is a rare malignancy in the modern Western world, with an incidence reported between 0.1 and 0.9 new cases per 100,000 males per year (1). For all patients presenting with squamous cell carcinoma (SCC) of the penis, approximately 50% have lymphatic involvement at the time of diagnosis. As with other SCCs, penile cancer typically spreads in a predictable manner to regional lymph nodes before distant metastases occur. Furthermore, lymph node involvement directly correlates with the grade, T stage, and lymphovascular invasion of the primary tumor (2). The progression of lymph node involvement is stepwise, with the superficial inguinal lymph nodes (ILNs) being the first site of metastasis, followed by the deep ILNs below the fascia lata and finally the pelvic lymph nodes (most commonly the obturator and external iliac nodes). Because the penile lymphatic drainage is bilateral, the minimal dissection should be a bilateral superficial lymphadenectomy, although there are rare exceptions to this rule. Based on intraoperative frozen sections, a more extensive lymphadenectomy may be required if the superficial ILNs are positive for metastases, and this may include deep ILNs and pelvic LNs.

The most important prognostic factors for invasive penile SCC remain the presence and extent of lymph node metastases (3). The TNM staging was updated in 2010 (Table 66.1) by the American Joint Committee on Cancer (AJCC), and there were significant changes made in nodal staging including extranodal extension (ENE) conferring N3 disease (4). Regional lymph node metastases undoubtedly confer a worse prognosis, although long-term survival can approach 60% with aggressive surgical extirpation. However, if the pelvic nodes are involved with SCC of the penis, 5-year survival rates are dismal and some report this rate as low as 0% (5). For patients with fixed or bulky lymphadenopathy, neoadjuvant chemotherapy regimens such as paclitaxel + cisplatin + 5FU or paclitaxel + ifosfamide + cisplatin have been used in recent trials (6,7). One recent study in men with N2 and N3 disease without distant metastasis completed four cycles of neoadjuvant chemotherapy, allowing 73% to undergo surgical extirpation and 30% remained alive and free of recurrence at a median follow-up of 34 months (8).

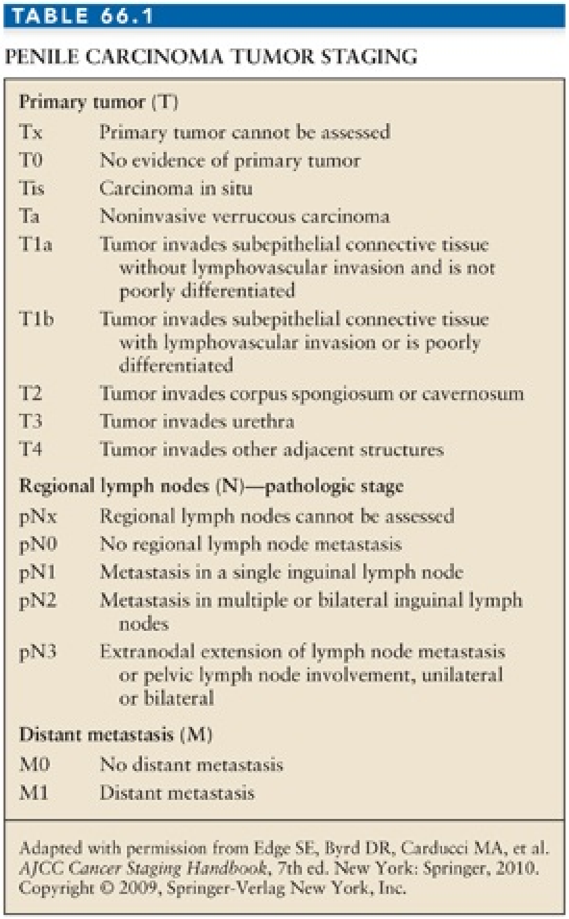

TABLE 66.1

PENILE CARCINOMA TUMOR STAGING

Primary tumor (T)	
Tx	Primary tumor cannot be assessed
T0	No evidence of primary tumor
Tis	Carcinoma in situ
Ta	Noninvasive verrucous carcinoma
T1a	Tumor invades subepithelial connective tissue without lymphovascular invasion and is not poorly differentiated
T1b	Tumor invades subepithelial connective tissue with lymphovascular invasion or is poorly differentiated
T2	Tumor invades corpus spongiosum or cavernosum
T3	Tumor invades urethra
T4	Tumor invades other adjacent structures
Regional lymph nodes (N)—**pathologic stage**	
pNx	Regional lymph nodes cannot be assessed
pN0	No regional lymph node metastasis
pN1	Metastasis in a single inguinal lymph node
pN2	Metastasis in multiple or bilateral inguinal lymph nodes
pN3	Extranodal extension of lymph node metastasis or pelvic lymph node involvement, unilateral or bilateral
Distant metastasis (M)	
M0	No distant metastasis
M1	Distant metastasis

Adapted with permission from Edge SE, Byrd DR, Carducci MA, et al. *AJCC Cancer Staging Handbook*, 7th ed. New York: Springer, 2010. Copyright © 2009, Springer-Verlag New York, Inc.

DIAGNOSIS AND CLINICAL STAGING

Although penile carcinoma is diagnosed by clinical exam, there are several adjunctive tools that have evolved to assist with staging and improve ultimate management for patients. These include computerized tomography (CT), magnetic resonance imaging (MRI), fluoride positron emission tomography (PET) scans, lymphangiography, and sentinel node biopsies. Lymphangiograms, however, have fallen out of favor with the recent advances in imaging and are now rarely used.

A proper clinical exam is crucial in identifying inguinal lymphadenopathy. When assessing the inguinal nodes, the patient should be in the “frog-leg” position, and the examiner stands on the ipsilateral side of the groin being examined. A manual exam should denote the location of any lymphadenopathy found and its relation to the femoral vessels. Palpable nodes are often documented as “shoddy,” “mobile,” “bulky,” or “fixed.” The most important delineation is whether or not the lymph nodes are amenable to surgical resection (i.e., are they fixed?). Obesity is commonly a limiting factor when performing an inguinal exam, and imaging is mandatory to accurately assess these patients. Approximately 25% of patients with clinically negative nodes will harbor metastatic disease at the time of inguinal lymph node dissection (ILND), whereas up to 70% with palpable lymphadenopathy (LAD) will have metastatic nodes (9).

Although CT and MRI have been used routinely to better stage the depth of invasion and assess for lymphadenopathy, newer imaging studies have improved on this task. (18)-Fluoride PET/CT has demonstrated a sensitivity of 80% and specificity of 100% for detecting lymph node metastasis. However, as with other imaging modalities, the major limitation is with identifying micrometastases, which are often missed. When used in conjunction with lymphotrophic nanoparticles, MRI has demonstrated a sensitivity and specificity for diagnosing positive lymph nodes in up to 100% and 97%, respectively (10).

Biopsy of the first order lymph node draining the penis, known as the sentinel lymph node, has long been sought after for identifying the extent of disease in penile carcinoma. Various modalities have been used over the last two decades including blue dye and nuclear scintigraphy. Recently, there has been a resurgence of dynamic sentinel node biopsies (DSNB), as it currently has improved accuracy in diagnosing metastatic inguinal lymph nodes. In a recent article, 264 patients who were all clinically node negative (cN0) had ultrasound-guided DSNBs, which was 95% sensitive for detecting metastatic penile carcinoma. This was done by injecting technetium-99m 4 hours prior to surgery and then injecting 1 mL of patent blue dye intradermally into the proximal penile shaft 1 hour prior to surgery. A gamma camera was then used to detect the highest amount of active radiotracer in the inguinal basins and this sentinel node was then excised (11). Negative ILNDs have been reported as high as 77% in patients with invasive SCC of the penis, and the use of DSNB may obviate unnecessary surgery in appropriately selected patients that are cN0 (12). In a meta-analysis of 18 studies, the highest sensitivity for DSNB was 92%, and this was achieved when using technetium radiotracers and blue dye for sentinel node mapping (13). DSNB can be a labor-intensive evaluation and the best results are in centers that have high volumes of penile carcinoma.

INDICATIONS FOR SURGERY

The primary risk factors for the development of inguinal lymph node metastasis remain tumor grade, depth of invasion (stage), lymphovascular invasion (LVI), and clinically palpable nodes (cN1). One recent study demonstrated that 68% of high-grade tumors, 49% with a depth of invasion >5 mm, 63% with LVI, and 54% who were cN1 had metastatic disease at the time of ILND (2). Others have reported that even grade 1 tumors can have a nearly 30% incidence of metastatic nodal involvement and those with T2 disease or higher can have up to a 60% rate of positive nodes (14,15). Nomograms have also been developed to help predict the risk of metastatic disease using the aforementioned parameters (16).

As a general rule, it is still advised that all patients with penile carcinoma receive 4 to 6 weeks of antibiotic therapy prior to ILND if palpable lymph nodes are identified, as up to 50% of these are reactive, inflammatory nodes at the time of diagnosis (17). Antibiotic therapy, therefore, may help distinguish pathologic from inflammatory nodes, and it also reduces postoperative infectious complications after inguinal node dissections.

The most recent European Association of Urology (EAU) guidelines from 2009 have published several recommendations for the management of regional lymph nodes. All of the recommendations listed are grade B from good clinical studies without randomization. Active surveillance is appropriate for patients with no palpable LAD and Tis, TaG1, and T1G1 disease, although close follow-up and clinical exams should be performed every 2 to 3 months. For those without LAD and T1G2 disease or higher, they advocate performing a DSNB followed by ILND if the DSNB is positive for malignancy. For patients with palpable LAD, either ultrasound-guided fine needle aspiration (FNA) or DSNB can be performed, followed by ILND if positive versus upfront ILND in those deemed to be higher risk. Pelvic LND is recommended for those with extranodal metastasis, node of Cloquet involvement, or two or more inguinal node metastases. Adjuvant chemotherapy is appropriate for patients with pN2 or pN3 disease after ILND, and neoadjuvant chemotherapy is appropriate for patients with fixed or relapsed LAD (6). A workflow outline for the management of penile cancer from Protzel et al. (18) is outlined in Figure 66.1.

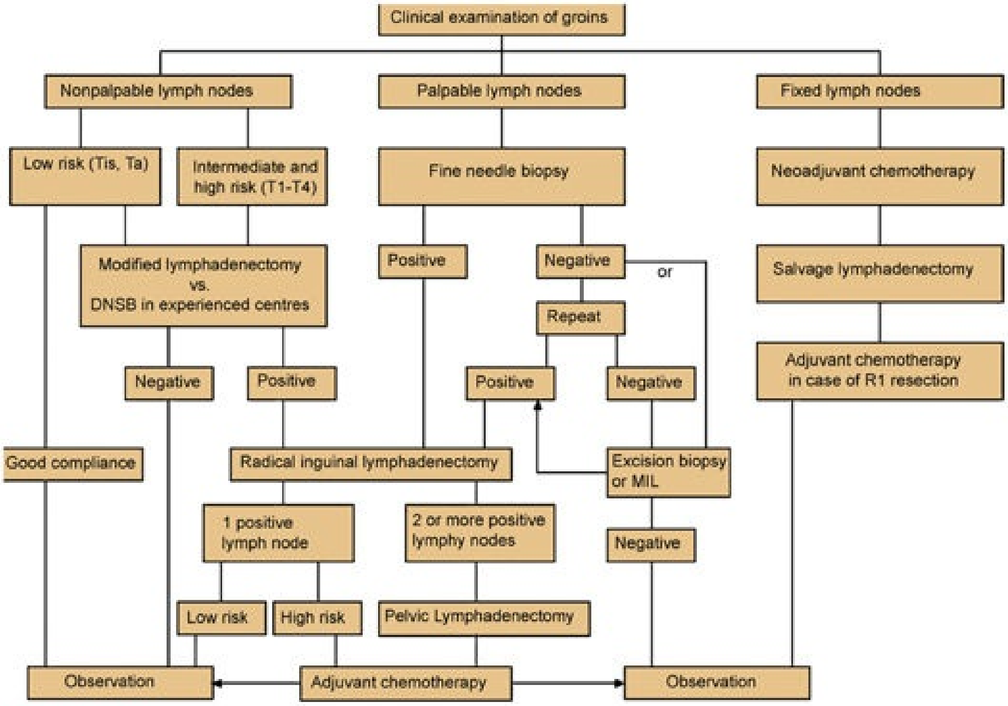

FIGURE 66.1 Workflow for the management of penile cancer patients regarding the inguinal lymph nodes based on this review. MIL, modified inguinal lymphadenectomy. (Reprinted with permission from Protzel C, Alcaraz A, Horenblas S, et al. Lymphadenectomy in the surgical management of penile cancer. *Eur Urol* 2009;55(5):1075–1088. Copyright © 2009, Elsevier. www.europeanurology.com.)

However, there are also some urologists who advocate upfront ILND in patients with high-risk, clinically node-negative disease without performing DSNB first. Due to the pitfalls of limited sampling, as with any biopsy, sentinel node biopsies are not completely accurate. Particularly, it may not detect patients with micrometastatic SCC of the penis that could be potentially cured by ILND. In a retrospective study comparing patients who had cT2-3N0M0 penile carcinoma, those with an upfront ILND had a 3-year overall survival (OS) of 84%, compared to 35% for those who were surveyed until they developed clinically palpable nodes (19).

Chemotherapy in SCC of the penis has only been shown to improve outcomes in the neoadjuvant setting with platinum-based regimens. Employment of this should be in patients with clinical evidence of inguinal node disease >4 cm in size. As mentioned earlier, Pagliaro et al. (8) demonstrated that of patients receiving TIP (paclitaxel, ifosfamide, and cisplatin) for four cycles, over 70% were able to undergo surgical consolidation. In this phase II trial, 50% had a complete or partial response. More importantly, 30% remained alive at a median follow-up of 34 months, which is almost double that of historical data (20). As for patients who are found to have pN2/3 disease post ILND, adjuvant chemotherapy with a similar regimen should be considered. However, this is an extrapolation based on data in the neoadjuvant setting.

PERIOPERATIVE PLANNING AND CARE

1. Metastatic workup should include the following:
    a. CT pelvis or abdomen/pelvis with intravenous (IV) contrast
    b. Chest X-ray (CXR), CT chest if pathologic abdominal findings
    c. Liver function tests
    d. Bone scan if clinically indicated
2. Four to 6 weeks of preoperative antibiotics covering skin flora (e.g., cephalexin)
3. One to 2 g IV cefazolin or 600 to 900 mg IV clindamycin within 1 hour of incision and should be continued for 24 hours perioperatively
4. Adequate hydration
5. Pneumatic compression stockings and 5,000 units of subcutaneous heparin q8 to 12 hours postoperatively
    a. Consider temporary prophylactic Lovenox for a longer duration in higher risk patients (prior deep venous thrombosis [DVT] or immobilization).
6. Continuous suction Jackson-Pratt (JP) drains should be placed in the inguinal beds until minimal output (<30 mL/day) to mitigate the risk of seroma formation, abscess, and wound necrosis.

SURGICAL ANATOMY

The extent of an inguinal lymphadenectomy continues to be of controversy. Although some centers still perform radical ILND in all patients with penile carcinoma, there is compelling data to suggest that a modified ILND may be more appropriate in correctly selected patients, particularly those who are cN0.

The superficial inguinal region is divided into four quadrants with the midpoint at the saphenofemoral junction. These quadrants all contain lymph nodes, which are known as the superomedial, superolateral, inferomedial, and inferolateral nodes (Fig. 66.2) (18). The superolateral nodes are near the superficial circumflex vein, the superomedial nodes are in proximity to the superficial external and superficial epigastric veins, and the inferomedial nodes are centered around the greater saphenous vein. It is crucial when dissecting in these areas that lymphatics and venous structures are meticulously dissected and ligated with permanent suture (e.g., 3-0 silk) to minimize the risk of lymphocele formation. Smaller lymphatics and veins can safely be divided using a LigaSure device or vascular clips.

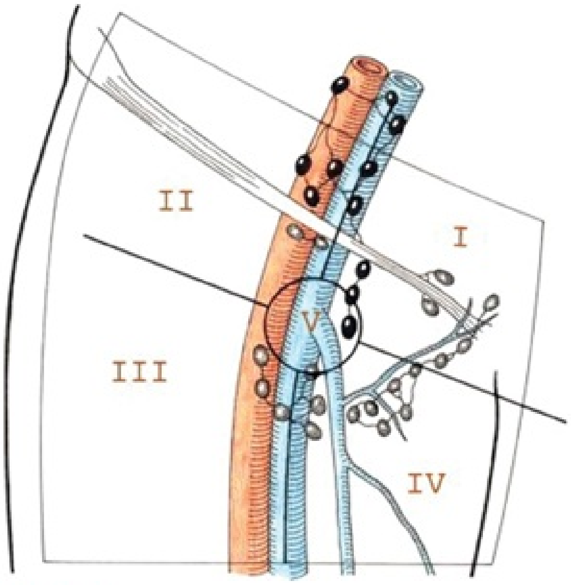

FIGURE 66.2 Lymphatic drainage regions of the inguinal-femoral canal. The region is divided into five zones: one central zone (*V*), superior (*I*) and inferior (*IV*) medial zones, and superior (*II*) and inferior (*III*) lateral zones. (Reprinted with permission from Protzel C, Alcaraz A, Horenblas S, et al. Lymphadenectomy in the surgical management of penile cancer. *Eur Urol* 2009;55(5):1075–1088. Copyright © 2009, Elsevier. www.europeanurology.com.)

Lymph node (LN) yield is quite variable with reported ranges between 4 and 25 LNs, with averages between 8 and 14 depending on the study (21,22). The superomedial quadrant contains the highest distribution of nodes with an average of four (21). It is also important to note that there are also central nodes located around the saphenofemoral junction.

The superficial and deep inguinal lymph nodes are separated by the fascia lata, which lies anterior to the femoral triangle. The femoral triangle is bound by the sartorius muscle laterally, the inguinal ligament superiorly, and the adductor longus muscle medially (Fig. 66.3) (18). The deep inguinal lymph nodes are located medial to the femoral vein with the superior extent of the dissection being the node of Cloquet found adjacent to the lacunar ligament. If any of these LNs reveal metastatic disease, then a pelvic LND is mandatory as the deep inguinal lymph nodes drain directly into the obturator, internal and external iliac lymph node basins.

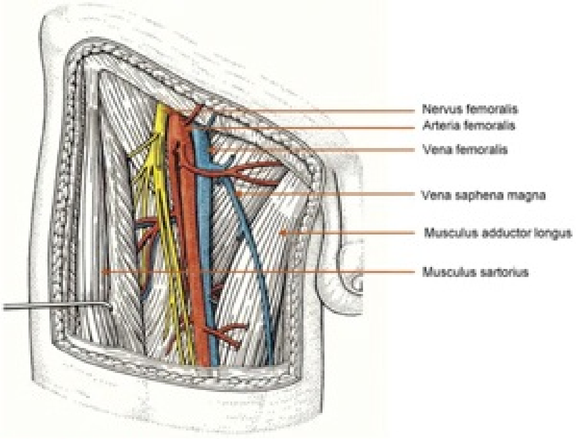

FIGURE 66.3 Surgical anatomy of the inguinofemoral region. (Reprinted with permission from Protzel C, Alcaraz A, Horenblas S, et al. Lymphadenectomy in the surgical management of penile cancer. *Eur Urol* 2009;55(5):1075–1088. Copyright © 2009, Elsevier. www.europeanurology.com.)

Finally, the arterial supply to the groin skin includes the superficial external pudendal, the superficial circumflex iliac, and the superficial epigastric arteries. Because these arteries are divided during an ILND, skin flap integrity relies on the arterial supply above Camper fascia.

Radical Inguinal Lymphadenectomy

The proper positioning for a radical inguinal lymphadenectomy (RIL) is with the patient supine and the ipsilateral lower extremity placed in a frog-leg position. The incision starts medially, two fingerbreadths lateral and inferior to the pubic tubercle. This incision is made in a “Z” shape toward the anterior superior iliac spine (ASIS) in the superolateral direction and extends to the most inferomedial aspect of the node dissection. The limits of an RIL are the inguinal ligament superiorly, extending from the pubic tubercle medially to the ASIS laterally. The lateral border of this dissection is 20 cm inferior from the ASIS and the medial border extends 15 cm below the pubic tubercle. The inferior limit joins the previously described lateral and medial borders along the upper thigh.

The first step of this dissection is to create skin flaps just below Camper fascia. Skin hooks can be used to create these flaps and mobilize the skin and subcutaneous fat off of the underlying Scarpa fascia. Meticulous care has to be taken to avoid making these skin flaps too thin, as this could lead to wound breakdown and necrosis. Army-Navy or Deaver retractors can be used to help elevate the skin flaps, which should be mobilized approximately 6 cm below and above the incision.

Next, dissection continues through Scarpa fascia onto the external oblique aponeurosis. The spermatic cord is then identified emerging from the external inguinal ring and retracted medially. All lymphatics along the spermatic cord and below Camper fascia are separated and ligated carefully to avoid postoperative lymphocele formation. These lymphatic packets are dissected off of the external oblique fascia to the inferior aspect of the inguinal ligament. Here, the femoral vessels can easily be palpated and identified within the femoral sheath. From lateral to medial, the femoral sheath contains the femoral nerve, artery, vein and lymphatics, respectively.

The medial border of the femoral triangle is the adductor longus muscle and the lateral border is the sartorius muscle, which are identified next in the dissection. The fascia lata overlying these muscles is then incised and the muscles are followed to their confluence at the most inferomedial aspect of the femoral triangle. The remainder of the lymphatics within the femoral triangle is then dissected out to complete the lymphadenectomy.

The saphenous vein can be identified medially in the femoral triangle, just medial and inferior to the fossa ovalis. Traditionally during an RIL, this vein was ligated; however, more recently, care has been taken to preserve the saphenous vein in order to minimize postoperative lymphedema. Occasionally, when there is bulky lymphadenopathy, the saphenous vein must be sacrificed in order to completely resect all disease. The femoral sheath overlying the femoral artery and vein is then incised and carried to the node of Cloquet, which is the most cephalad extent of the deep dissection. The sheath is opened inferiorly to the junction of the adductor longus and sartorius muscles. All lymphatic tissue between the femoral artery and vein is then dissected out carefully. Some superficial cutaneous arteries and veins are ligated as they come off the femoral vessels. Care must be taken not to extend the dissection too laterally or posterolaterally, as the femoral nerve and profunda femoris artery are in this location and subject to injury.

Once the dissection is completed, the wound is irrigated copiously and a sartorius flap is then mobilized off of its insertion on the ASIS. It is rotated over the femoral vessels and sutured to the cephalad portion of the inguinal ligament with several interrupted permanent sutures. Care must be taken during mobilization of the sartorius muscle, particularly medially, where its blood supply is derived. The medial aspect of the sartorius muscle can also be reapproximated to the adductor longus muscle for better coverage of the femoral vein. To prevent an inguinal hernia, Cooper ligament can be sutured to Poupart ligament with interrupted 2-0 Prolene. A JP drain is brought out inferior to the incision and then the Scarpa fascia is then sutured together incorporating some of the underlying sartorius muscle to minimize the dead space. The skin is then closed with a running subcuticular 4-0

Monocryl suture. Sterile dressings are placed over the incisions for 48 hours and the patient is allowed to ambulate on postoperative day 1. Additionally, patients should wear antiembolic stockings that extend above the knee for 3 to 6 months postoperatively.

Modified Inguinal Lymphadenectomy

The modified inguinal lymphadenectomy (MIL) was first proposed by Catalona (23) in 1988 that had several benefits which are listed as follows: a shorter 10-cm incision, preservation of saphenous vein to mitigate lymphedema risk, avoiding dissection lateral to the femoral artery, and eliminating the need for a sartorius flap. Patient positioning is the same as that for an RIL, with the thigh abducted and externally rotated and a pillow placed underneath the knee. Again, a 10-cm curvilinear incision about 2 cm below the inguinal groin crease is made extending it toward the ASIS. Skin flaps are developed at a minimum of 6 cm superior and inferior to the incision. They should be covered with saline-soaked gauze and handled gently to prevent necrosis. Rarely, the skin may be fixed and involved when there is bulky lymphadenopathy present and therefore must be excised. A muscle flap can then be rotated into this space for coverage.

The cephalad and medial extent of the MIL is identical to the radical lymphadenectomy, but dissection laterally is limited to the femoral artery as previously alluded to. The sartorius muscle is not exposed during this dissection and the saphenous vein is preserved when removing the superficial nodes. The dissection inferiorly along the fascia lata and femoral sheath extends to the inferior border of the fossa ovalis as opposed to the confluence of the sartorius and adductor longus muscles in the radical lymphadenectomy. Should a deep dissection be mandatory, all lymphatics between the femoral artery and vein are removed as well.

Some important limitations of the modified inguinal lymph node dissection are its reliance on frozen sections, which may dictate whether a deep inguinal dissection is to be performed. Given the rarity of penile carcinoma in the modern Western world, some centers may not have pathologists who have adequate exposure to penile cancer cases. Therefore, low-volume centers may not accurately diagnose patients with metastatic penile carcinoma on frozen sections and subject them to inferior outcomes. It is our belief that penile carcinoma cases should be referred to high-volume centers of excellence in order to optimize surgical outcomes.

Suprainguinal Dissection in Inguinal Lymphadenectomy

Occasionally, penile carcinoma metastases may be found above the inguinal ligament, which dictates a different approach in surgical extirpation. In some cases, the metastases found may be above the inguinal ligament. The incision is made about 2 cm above the inguinal ligament and extends from the pubic tubercle medially to the anterior superior iliac spine laterally. The standard groin dissection as previously described can be performed through a suprainguinal incision, albeit the most inferior aspect of the dissection may be more difficult due to poorer exposure. However, most centers that perform suprainguinal dissections have found that the skin flap viability is comparable or even better than a subinguinal incision due to less retraction of the skin when dissecting around the femoral vessels.

Laparoscopic and Robotic-Assisted Inguinal Lymphadenectomy

Further surgical advancements have been made in recent years and the feasibility of laparoscopic and robotic-assisted approaches to inguinal lymphadenectomy have been realized. In a recent phase 1 prospective trial, the oncologic adequacy of robotic-assisted video-endoscopic inguinal lymphadenectomy (RAVEIL) was tested (24). This study included 10 patients with cT1-3N0 penile carcinoma with a mean of nine lymph nodes removed per groin. Only 2 of the 10 patients had metastatic disease and 95% of the inguinal lymph node dissections performed were inspected and determined free of residual lymphatic tissue requiring excision. The surgical technique includes a 1.5-cm incision made 2 to 3 cm below the apex of the femoral triangle. Once Scarpa fascia is opened, a balloon dilator is inserted and inflated to 800 mL to create adequate working space for the robotic instruments. Only three ports are used for the dissection, a 10-mm camera port and two 8-mm robotic trochars. Operative times ranged from 3 to 4 hours to complete bilateral ILNDs and there were only two minor complications (cellulitis and an inguinal abscess requiring incision and drainage). Thus, morbidity may be decreased by a minimally invasive approach.

Similarly, a standard laparoscopic inguinal approach has been reported by several groups with similar oncologic efficacy to the open ILND (25,26). Typical port placement involves three trochars: one placed at the apex of the femoral triangle, one lateral to the sartorius muscle, and one medial to the adductor longus. In one study involving 32 patients, their mean operative times were 165 minutes and the mean node count was 11 per groin. Complications were minor in nature, with 18% having postoperative wound infections and cellulitis being the attributable cause in the majority of cases.

Flap Reconstruction after Inguinal Lymphadenectomy

After radical inguinal lymphadenectomy, particularly in the case with bulky disease, flap coverage may be required to protect the femoral vessels in addition to split-thickness skin grafting for wound coverage. The goal of both is to mitigate the risk of wound necrosis and also protect the femoral vessels from rupturing, particularly in cases where adjuvant radiation may be necessary. The most commonly described flaps are as follows: fascia lata myocutaneous flap, gracilis flap, abdominal rotational flap, rectus abdominis myocutaneous flap, deep inferior epigastric artery myocutaneous flap, and a thigh rotational flap. The sartorius muscle flap, as previously described, is one of the most common methods used to cover the femoral vessels.

The inferior rectus abdominis myocutaneous flap is another commonly employed technique for vessel and skin coverage in patients with large defects. A flap from the contralateral rectus abdominis is used and tunneled under the subcutaneous tissue and placed anterior to the ipsilateral rectus abdominis muscle. If there is a large inguinal skin defect, an elliptical area of lower abdominal skin can be used with the rectus abdominis flap for coverage. Otherwise, a split-thickness skin graft can be used to bridge skin coverage.

COMPLICATIONS

There are several common complications following inguinal lymph node dissections of which skin edge necrosis is the most common, ranging from 45% to 62% in several studies. This complication has been reduced to nearly 10% in more recent reports by modifying surgical technique (27). Some simple steps to prevent skin necrosis are to use an incision below the inguinal fold, meticulous handling of the skin flaps, avoid tension by reapproximating the skin flaps to the underlying muscle aponeurosis, and to make sufficiently thick flaps that incorporate both Camper and Scarpa fascia. Split-thickness skin grafting may be required if there is significant skin loss.

Lymphedema is the second most common complication reported ranging from 23% to 50% (28,29). As previously stated, this can be prevented by meticulous ligation of lymphatics and preservation of the saphenous vein, but the risk increases significantly when a deep inguinal node dissection is performed. There are several conservative methods of improving lymphedema which include elevation of the affected lower extremity, range of motion exercises, elastic stockings, 24-hour ACE wraps, and diuretics (30).

Wound infection and seroma formation are frequently reported in 10% to 15% of cases. Most infections can be treated conservatively with intravenous antibiotics with good gram-positive bacterial coverage. Also, a chlorhexidine scrub within 24 hours of surgery may help minimize the risk of wound infections. Complex wound infections that require opening the incision can be managed by wound vacuum-assisted closure (VAC) devices to expedite wound closure. Vascular injuries and DVT are rare complications with a reported incidence between 0% and 10%.

SUMMARY

SCC of the penis is a rare malignancy in the Western developed world and, consequently, few controlled studies have been completed to delineate the optimal management of lymphatic dissections. It is crucial to have an accurate pathologic diagnosis, as this ultimately determines the type of treatment a patient will receive. It is important to remember that T stage, lymphovascular invasion, and histologic grade all strongly correlate with the presence of malignant nodal involvement. Of particular note is the new AJCC criteria identifying extranodal extension, which confers a worse prognosis. According to the EAU guidelines, all patients with cT1G2 disease or worse should undergo DSNB followed by ILND, although ILND alone may be more prudent in lower volume centers that have less experience with sentinel node biopsies due the inherent pitfalls in its diagnostic accuracy. Upfront ILND is also appropriate in invasive penile carcinoma even in the absence of clinically positive nodes, as this has been shown to improve overall survival.

For patients with fixed or large lymph node masses, neoadjuvant chemotherapy has been demonstrated to have a 50% response rate with a doubling of overall survival as compared to historical data. A multidisciplinary approach is crucial in providing the best care for patients with metastatic penile carcinoma.

The key surgical tenets of inguinal lymph node dissections are as follows: create sufficiently thick skin flaps, meticulously handle the skin flaps, preserve the saphenous vein to minimize lymphedema, use musculocutaneous flaps appropriately to protect the femoral vessels, and make an incision that avoids the groin crease to prevent wound necrosis and maceration.

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CHAPTER 67 SURGICAL TREATMENT OF PEYRONIE’S DISEASE

BROOKE EDWARDS AND RAMÓN VIRASORO

Peyronie's disease (PD) is a scarring disorder of the tunica albuginea leading to penile deformity (Fig. 67.1). PD is a completely clinically established entity; still, its etiology is uncertain. Several theories have been proposed since its first description in the mid-18th century, but none has been confirmed yet (1–3). To the authors' knowledge, the development of PD is related to the unique anatomy of the tunica albuginea and its relationship to the septal fibers. The most accepted etiology seems to be the occurrence, in genetically susceptible individuals, of repetitive minimal trauma during sexual life. Unidentified buckling injuries of the penis will eventually lead to scarring and penile deformity (4). Only a few patients relate the onset of symptoms to a specific penile injury during sexual intercourse.

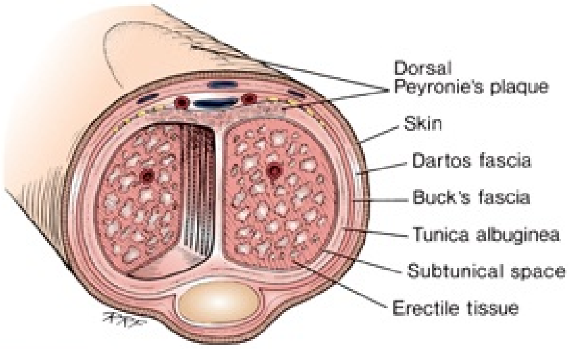

FIGURE 67.1 Cross-sectional penile anatomy with dorsal Peyronie's plaque.

The incidence of PD has recently been estimated at up to 3% or as high as 7% to 9% of the general male population (5,6).

CLINICAL PRESENTATION

The most frequent presentation is the development of penile curvature, but decrease in penile length, indentation, hinge deformity, and erectile dysfunction are very common complaints (Fig. 67.2).

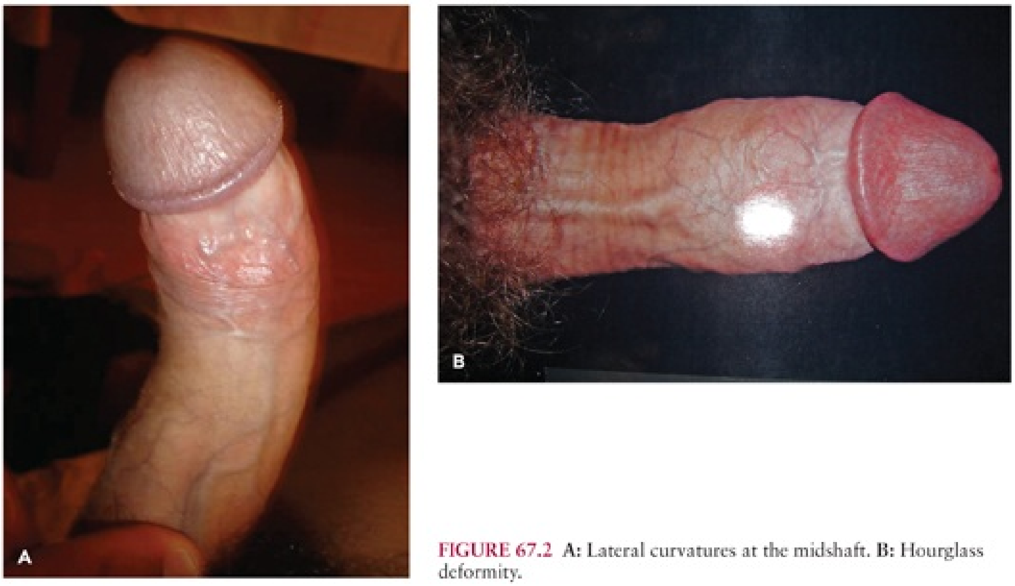

FIGURE 67.2 A: Lateral curvatures at the midshaft. B: Hourglass deformity.

Clinically, PD has two phases. The first, an active phase, is commonly associated with painful erections and changing deformity of the penis. It is followed by a quiescent secondary phase, characterized by deformity stabilization, disappearance of painful erections, if they were present, and, in general, stability of the process. Up to a third of patients, however, present with what appears to be sudden “overnight” development of painless deformity.

DIAGNOSIS

The diagnosis of PD is mainly clinical, based on a detailed history and physical examination. Recollection of onset, duration, and progression of penile deformity is crucial as well as any degree of sexual dysfunction. Erectile dysfunction, if present, is multifactorial because many of these patients have preexistence comorbidities. The psychological impact of the disease plays an important role.

The physical examination should be focused on delineating plaque location, size, and penile sensitivity because many patients complain of hypoesthesia. Decrease in penile sensitivity needs to be established for this is a common postoperative complaint, and basal sensitivity needs to be established. In an attempt to elicit known disease associations such as Dupuytren’s contracture or other elastic tissue fibromatosis, an examination of hands and feet should be made. Objective evaluation of penile curvature with home-taken photographs of the erect penis, we find, is extremely helpful, but other authors have found it most useful to perform an artificial erection with vasoactive substances at the time of office visit. Curvature is then measured using a goniometer or protractor. Plain radiographs are effective in demonstrating plaque calcification (Fig. 67.3). The presence of calcifications, once believed to be a sign of plaque maturity, is now debatable, for recent reports have shown it to be more prevalent and present early in the onset of symptoms (7). Plaque calcification is also easily demonstrated with ultrasonography (8). The plaque can be imaged by both computerized tomography (CT) and magnetic resonance imaging (MRI), both being unnecessary except for the possibility of using MRI to “stage” the phase of disease for research or study protocol purposes, or in a rare patient where the diagnosis is not certain and a concern for a possible malignancy arises (9).

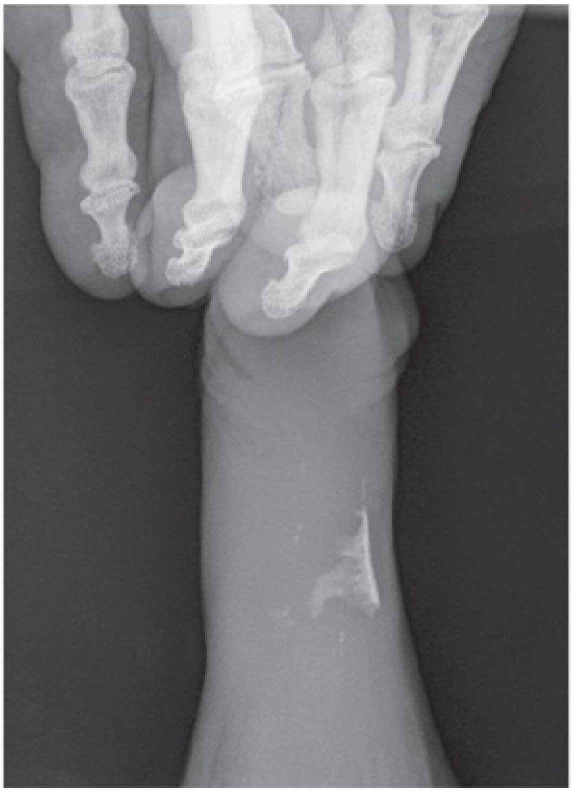

FIGURE 67.3 Prominent calcification of a dorsal plaque.

It is important to evaluate and define the surgical candidate’s preoperative erectile function. Prospective surgical patients, at our center, are evaluated with color duplex ultrasound in the presence of pharmacologically induced erection. Abnormalities in the resistive index and end-diastolic velocity, at our institution, prompt further testing with dynamic infusion cavernosometry/cavernosography. In addition, one must determine if acceptable intercourse can be accomplished by enhancement of erectile rigidity alone. In this scenario, patients may be best served with a pharmacologic erection program as an alternative to surgery.

INDICATIONS FOR SURGERY

A frank discussion of treatment goals with the couple is imperative. The patient should be assured that the process is not malignant or life-threatening. The goal of surgery is to straighten the penis and maintain erectile function so that satisfactory intercourse can be achieved.

Couples must be aware that preexisting penile shortening and erectile dysfunction will not be improved by straightening procedures. Rigidity may be improved by straightening the penis, but truly improved erectile function does not occur. Evaluation with a sex therapist can help patients and partners adjust to these new sexual expectations.

Surgical candidates must have stable and mature disease, which includes resolution of pain and stabilization of curvature or other deformity. Fortunately, only a small proportion of patients with PD have deformity requiring surgical intervention. Surgical intervention should be regarded as palliation of the deformity only and not as cure.

In essence, one can correct the penile curvature by “shortening” the long aspect of the curve or by “lengthening” the short aspect of the curve. Additionally, in those patients with PD and associated severe erectile dysfunction, the option of a penile implant with plaque modeling or incision with or without grafting is valid.

Several surgical techniques have been described to correct penile curvature associated with PD, including plication of the opposite aspect of the lesion and incision/excision of the plaque and grafting. The tissues and materials applied to graft the corporal defect include dermis, tunica vaginalis, cadaveric dura mater, temporalis fascia, veins, cadaveric pericardium, and porcine small intestine submucosa (SIS) (10–16).

SURGICAL TECHNIQUE

Skin Incision

At our institution, we perform all Peyronie’s corrective procedures in supine position and use either a circumcising incision and penile degloving or an optional ventral midline incision for ventral plications. If the patient has been previously circumcised, then the incision should be performed through the circumcision scar. Once the incision has been made, an artificial erection is created with a pressure infuser device or butterfly needle and syringe with injectable 0.9% normal saline. We tend not to employ the use of a tourniquet to control bleeding or maintain an artificial erection because it is unneeded and tends to distort the presence of a proximal curvature. Some authors use vasoactive substances, such as papaverine or PGE, for this purpose.

Corporoplasty or Corporoplication Procedures

Several techniques and modifications have been published that describe methods of plication, or shortening of the convex side of the curvature. The techniques fall into (a) nonincisional plication, (b) incisional plication, or (c) excisional plication categories.

Nonincisional or 16-Dot Technique

Gholami and Lue described a 16-dot plication (17). They initially begin with obtaining an artificial erection with papaverine and ring or incisional block with bupivacaine. If a dorsal curvature is present and circumcision incision is not preferred, then the ventral longitudinal incision is made in the midline over the expected point of plication. Adjacent to the corpus spongiosum, a longitudinal incision is made in Buck’s fascia, exposing the tunica albuginea along the full length of the curvature. With a full erection present, the center of the curvature is marked on the ventral side. About 2 to 3 mm lateral to the corpus spongiosum, four dots are made in longitudinal arrangement to mark entry and exit points for the suture needle, each about 0.5 to 1 cm apart. Each four dots represent a single suture. Typically, two to three sutures are required on each side of the corpus spongiosum, which creates the 16- or 24-dot technique. A 2-0 braided, polyester, nonabsorbable suture is placed in an “in, out, in, out” technique with full-thickness bites of tunica albuginea. Each suture is placed and each serially tied down with a single throw or half knot before clamping with a rubber-shod clamp. After each is clamped, a full erection is again obtained to evaluate for correction of curvature. Each suture can then be adjusted to obtain straightness prior to tying down all sutures.

Ventral curvature can be corrected in a similar manner with the sutures placed between the deep dorsal vein and dorsal arteries on each side. Lateral curvature is corrected by placing the sutures on the lateral convex side, under the neurovascular bundles.

Excisional Technique (Nesbit [18], Pryor–Fitzpatrick [19])

Again, either a longitudinal or circumcising incision can be used. For dorsal curvature, the corpus spongiosum is dissected from the corpora cavernosa and retracted away with a Penrose drain. Beneath the corpus spongiosum, an area is marked exactly the point of greatest concavity. An ellipse of full-thickness Buck’s fascia and tunica albuginea is then excised over this area. The ellipse should be 0.5 cm in width and about one-third the circumference of the corpora cavernosa for a 45-degree deformity. For more severe curvatures, requires a wider ellipse, such as 0.8 cm for a 90-degree deformity. Approximately 1 mm for every 10 degrees of curvature is rule of thumb.

You can also choose to leave the corpus spongiosum in place and an excise an ellipse on each side the corpus spongiosum. A 3-0 nonabsorbable suture can be used in interrupted fashion to close the ellipse longitudinally with the knots buried inward to prevent the patient discomfort. An artificial erection should then be created to access for leaks or remaining curvature. Additional interrupted sutures can be placed to correct for a leak while an additional incision can be made to further correct any curvature. If the corpus spongiosum was dissected, then it can be replaced and anchored with fine suture noting that some redundancy can be expected.

Incisional Technique (Heineke-Mikulicz, Yachia [20])

A similar circumcising or longitudinal incision is made. Once Buck’s fascia is dissected off, a 1-cm longitudinal incision is made in the tunica albuginea. The incision is then closed transversely with interrupted 3-0 synthetic absorbable sutures. This is completed without excision of the tunica. Buck’s fascia is then reapproximated to better cover the sutures.

Prior to making an incision in the tunica albuginea, temporary plication sutures similar to that described in the 16-dot technique can be placed and evaluated with an artificial erection. The incision length or position can then be adjusted to correct the curvature. Once in correct position, fluorescent green dye is used to mark the position before the suture is removed and the incision is made.

Plaque Incision/Excision and Grafting

Depending on the technique to be used and the location of the plaque, the incision is planned. Most patients presents with a dorsal plaque because ventral location is very rare. We do not recommend ventral grafting because it has shown poor results on previous series. Dorsal plaques are most effectively approached using a subcoronal circumferential incision. In previously circumcised patients, the incision should be placed through the original circumcision scar to avoid possible future distal shaft and/or glans lymphedema.

Once the superficial Buck’s fascia has been achieved, the penis is degloved to its base, following a “webbed” avascular plane. Small perforators are controlled with a fine-tipped bipolar electrocautery (Fig. 67.4).

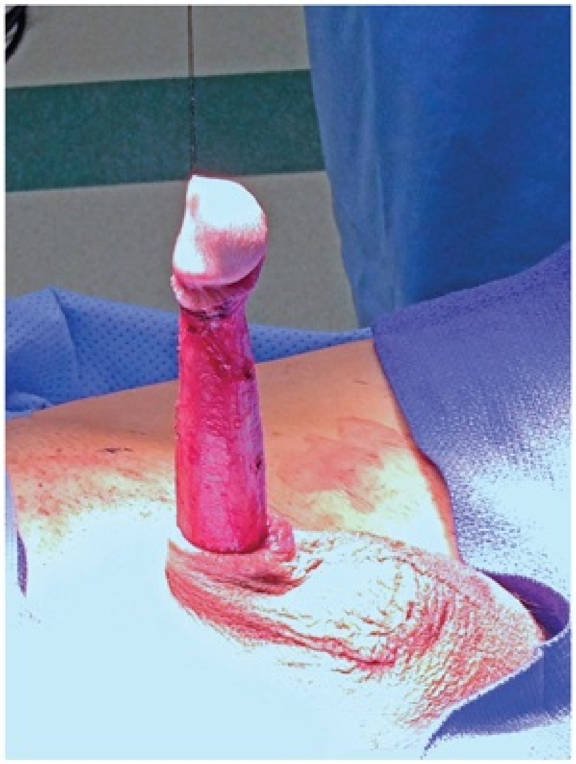

FIGURE 67.4 Aspect of the penis after penile degloving.

For dorsal plaques, the neurovascular bundle is then elevated in concert with Buck’s fascia. This can be accomplished mainly by two approaches. Lateral incisions to the corpus spongiosum are made, with Buck’s fascia and the dorsal neurovascular bundle dissected off the lateral and dorsal aspects of the corpora cavernosa. Alternatively, we currently approach dorsal plaques by dissecting sharply through the bed of the deep dorsal vein and perform a modified vein dissection (Fig. 67.5). We extend proximally to the penopubic junction and distally to the arborizations of the dorsal vein at the corona of the glans penis. Again, circumflex veins are controlled with the bipolar electrocautery.

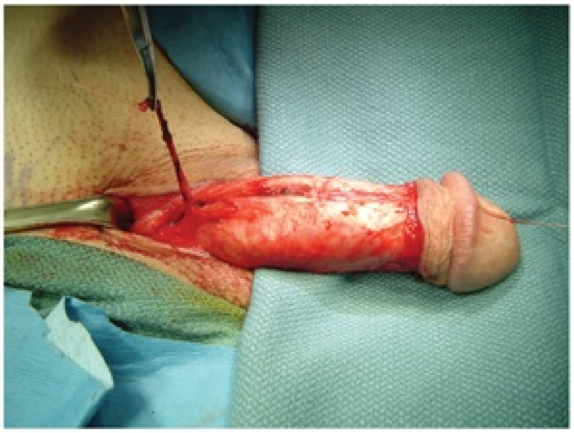

FIGURE 67.5 Deep dorsal vein dissection and ligation.

After dorsal exposure of the tunica albuginea, an artificial erection is performed to determine the extent of the plaque, and the point of maximal curvature is marked with a Prolene suture. In experienced hands, the inelasticity of the plaque can be evident by palpation, and feeling the surface of the tunica albuginea can delineate its extent. We place Prolene stay sutures in the midline, proximal and distal to the plaque, and lateral to the plaque, and then mark the planned incisions (Fig. 67.6). As we mention before, we do not favor the use of a tourniquet for either control of bleeding or induction of an artificial erection, as tourniquets can conceal proximal curvatures.

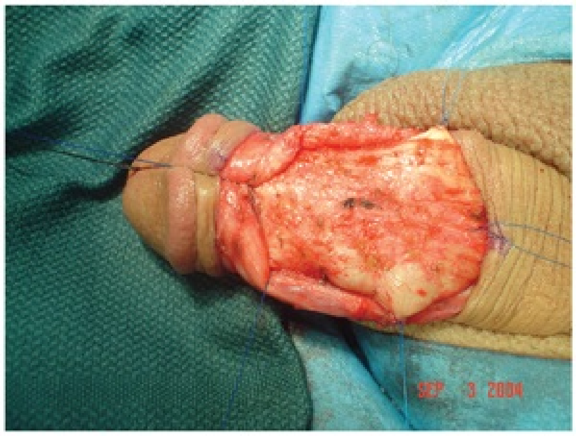

FIGURE 67.6 Tacking sutures exposing the dorsal plaque; the dorsal neurovascular structures were displaced laterally.

At this point, an H-shaped incision is created in the tunica albuginea (Fig. 67.7). The tunical flaps are elevated using sharp scissors or knife, allowing them to slide over the underlined erectile tissue (Fig. 67.8), and then are sutured leaving an approximately square defect (Fig. 67.9). Since 2001, we modified the sliding H incision. At the point of maximal curvature, which can be very accurately identified during artificial erection, a strip of tunica albuginea is excised (Fig. 67.10). This indeed does create a larger corporotomy defect; however, the defect remains approximately square and the graft inlay can be placed without difficulty. After either H incision or incision/excision is created, the sliding flaps are sutured. If there is indentation, the flaps are darted, allowing for expansion.

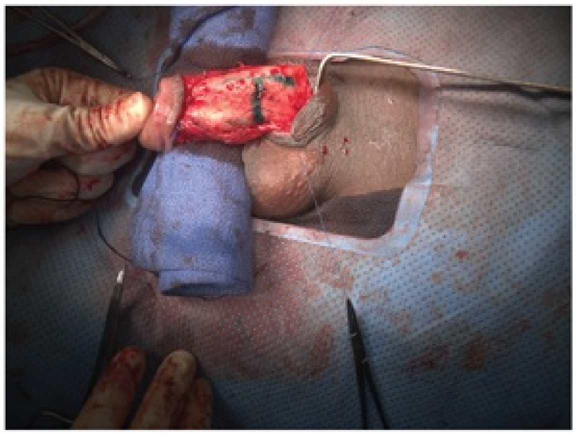

FIGURE 67.7 An H-shaped incision marked at the point of maximal deformity; the stitch marks that point.

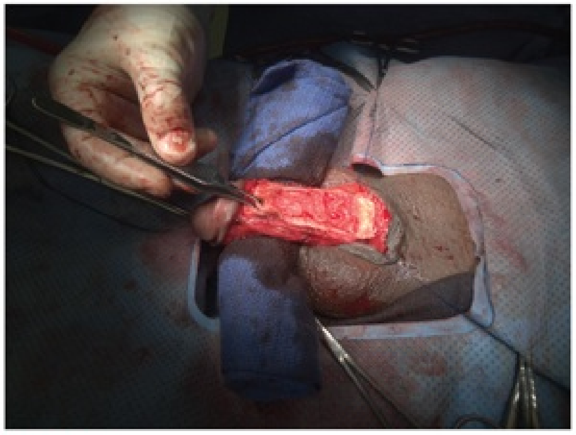

FIGURE 67.8 Incision of the tunica albuginea. Flaps are created to allow tissue sliding and elongation.

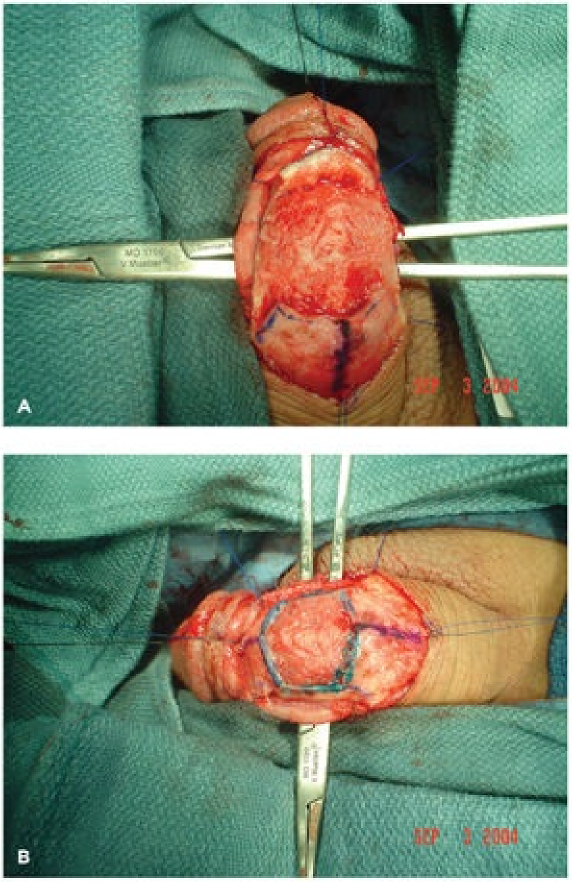

FIGURE 67.9 **A:** The defect after sliding flaps; this maneuver is extremely important in achieving straightening with this technique. Note the expansion of the corporotomy defect. **B:** Creation of a square defect in the tunica albuginea.

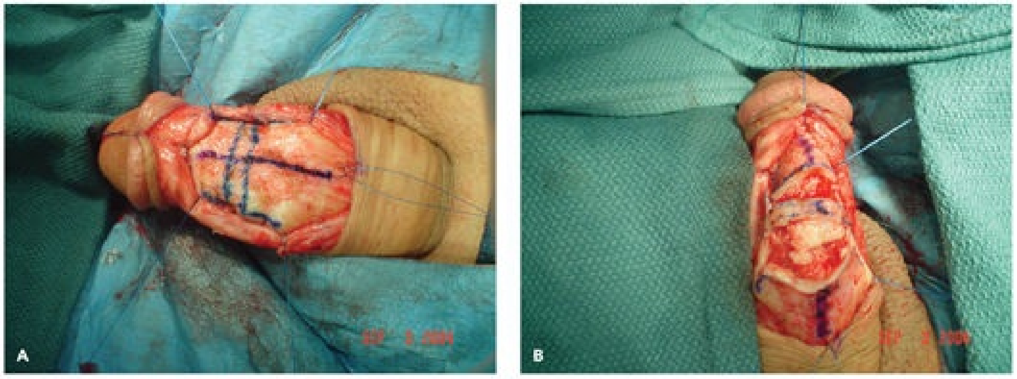

FIGURE 67.10 A and B: Modification of the sliding H technique in which a small strip is excised at the point of maximal curvature; the stitch marks that point.

It is clear that the penis can be effectively straightened with the incision and graft technique alone in about 70% of patients. The addition of the small strip excision allows for straightening in almost all patients. Only about 5% of patients will require touch-up plication, and generally that is for persistent tilt of the glans.

Once the plaque has been incised or excised, depending on the technique selected, we measure the defect, stretching the penis to ensure accurate coverage.

Dermal Graft

Since its first description by Devine in the early 70s (10), at our institution, we have used the dermal graft as the preferred method, although in recent years, the tendency has shifted toward the use of off-the-shelf grafts, specifically the SIS (porcine jejunal submucosa). The dermal graft is outlined on the donor site, considering that the graft, when released from the inherent tissue tension at the donor site, “contracts” about 30%. This should not be confused with graft contraction during “take.” We prefer to use the skin of the abdomen just above the iliac crest, lateral to the hairline as the donor site for the dermal graft. The donor site is closed per primam with subcuticular sutures, using either a pullout or the newer absorbable long-acting monofilament suture (Fig. 67.11).

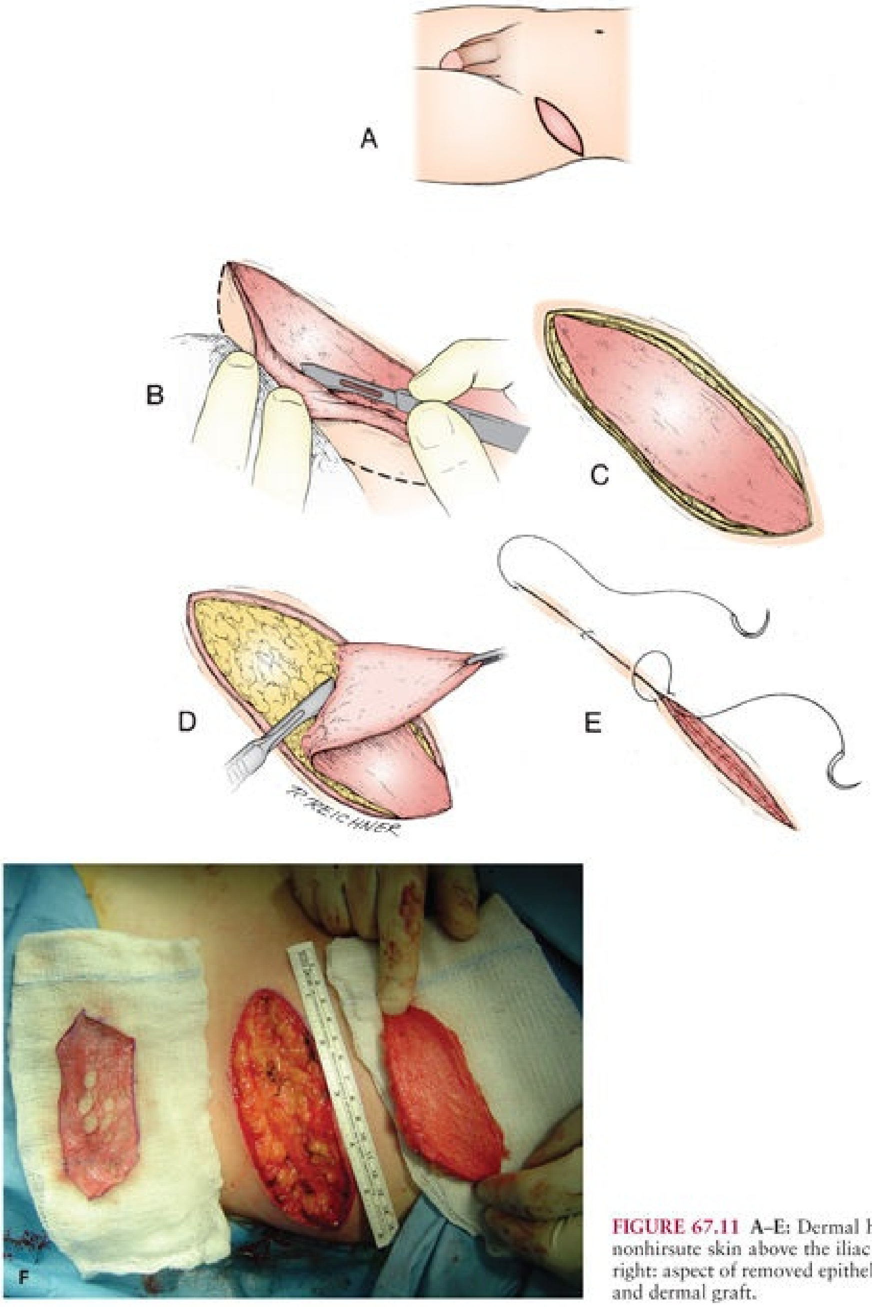

FIGURE 67.11 **A–E:** Dermal harvest from the nonhirsute skin above the iliac crest. **F:** Left to right: aspect of removed epithelium, donor site, and dermal graft.

We then carefully tailor the graft to measure approximately 30% larger in all dimensions than the corporotomy defect and place it into the defect (Fig. 67.12). After completing the graft inlay using 4-0 polydioxanone suture (PDS), we perform another artificial erection to demonstrate that the penis is straight and the suture lines are watertight (Fig. 67.13). If there are leaks, they are oversewn. If the penis is not straight during surgery, it will not be straight postoperatively. If curvature persists, therefore, further modification by means of incisions and grafting or “touch-up” plications is necessary.

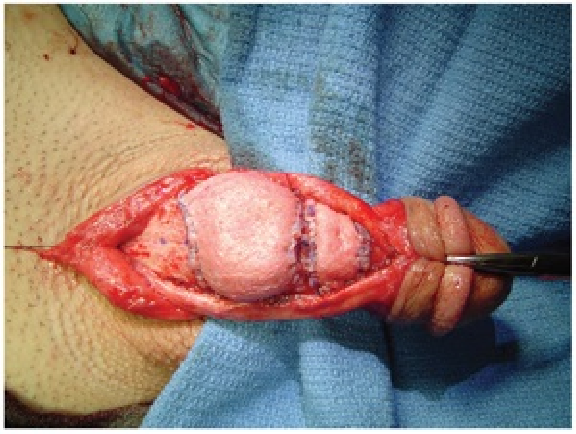

FIGURE 67.12 Watertight closure of the corporotomy after dermal graft.

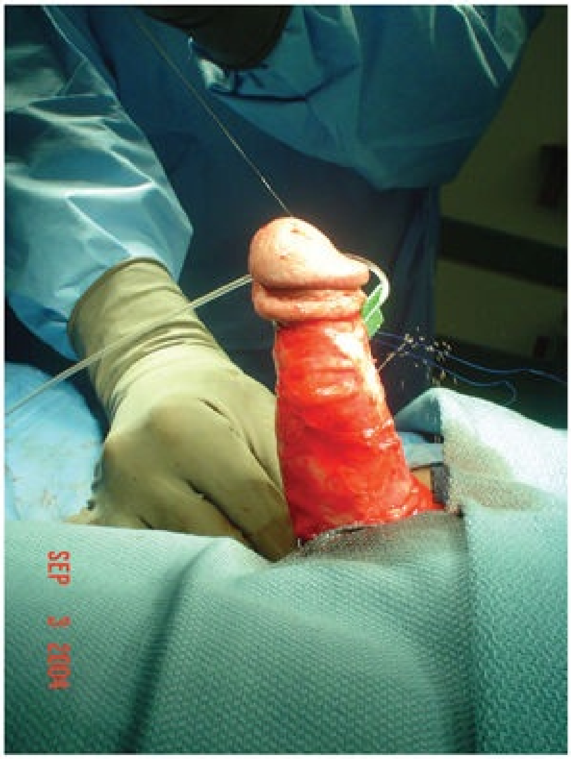

FIGURE 67.13 Artificial erection confirms penile straightening.

After completion of the dermal graft inlays, we anatomically close the penis. Buck's fascia is reapposed using PDS, and two small suction drains are placed superficial to Buck's fascia but deep to the dartos layer. We close the skin incisions using either chromic or small Vicryl sutures. If a ventral midline incision was created that crosses the penoscrotal junction, a Z-plasty should be used to prevent penoscrotal tethering.

Small Intestine Submucosa Graft (Surgisis Biodesign, Cook Medical Inc, Bloomington, IN)

Since early 2002, we have been using more frequently SIS graft than dermal graft. Recent comparative reports (21,22) have shown to be at least equivalent to the dermal graft. In this case, lyophilized (freeze dried) porcine jejunal submucosa (SIS) is immersed in normal saline and then appropriately tailored to oversize 30% of the tunical defect. The graft is sutured with watertight running 4-0 polyglycolic suture (Fig. 67.14). Another artificial erection confirmed the penile straightness (see Fig. 67.13).

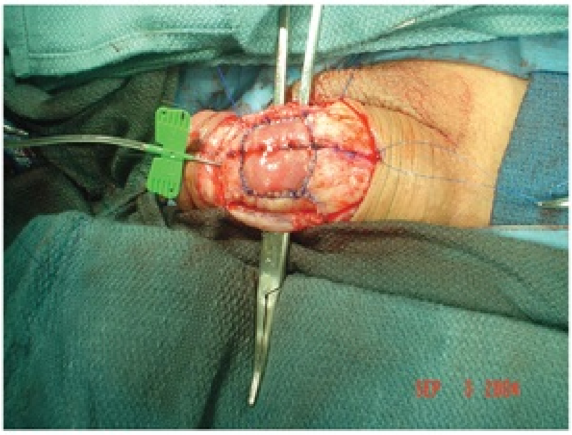

FIGURE 67.14 Watertight closure of the corporotomy after SIS graft.

Wound is closed in layers, leaving a 10Fr subfascial drainage for 24 hours. The penis is dressed with a Bioclusive dressing, loosely applied and extending from the base of the penis to the level of the mid glans to avoid sliding. A mildly compressing Kling dressing is wrapped over the Bioclusive dressing to limit edema and allow better collapse of the surgical spaces around the suction drains. The Kling dressing is left in place for 4 hours, during which the glans is checked every 30 minutes. A 14Fr Foley catheter is left until the patient ambulates on the morning after surgery. The suction drains are removed on the first postoperative day, and usually, the patient is discharged on that day. We suppress erections with diazepam and amyl nitrite and instruct patients to avoid them for about 2 weeks.

Dermal grafts mature in the same manner as other grafts: first nourished by imbibition of tissue fluids the first 48 hours, whereas inosculation occurs from adjacent blood vessels after the second day. Remodeling takes place during the late phase of maturation, with the graft tending to first contract and then become compliant. In the first 3 months, the graft may contract enough to re-create some of the curvature, but, as the graft softens, straightening occurs. Patients should be forewarned of this sequence of events to avoid undue anxiety.

After the first 2 weeks, we encourage patients to have erections but discourage them from intercourse for about 10 to 12 weeks. During this time, it is desirable for the penis to be manipulated so that the skin does not adhere to the deeper layers of the penis. In addition, erections stretch the graft and aid in the maturation phases of graft take. In some patients, we encourage the use of the vacuum erection device without the constriction ring as a means of distending and stretching the graft.

Penile Prosthesis in Peyronie’s Disease

The consensus committee on PD at the World Health Organization’s Second International Consultation on Sexual Dysfunctions states that penile prosthesis is a reliable option for the older man with vascular impairment, erectile dysfunction, and acquired deformity of the penis (23). It is not the only treatment in PD but rather prudent treatment for the patient with significant erectile dysfunction in association with their PD. Hydraulic prostheses are preferred, and those prostheses that have true controlled expansion cylinders have been shown to provide better results.

The technique of penile prosthesis implantation is covered elsewhere in this book.

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CHAPTER 68 ■ PRIAPISM

ARTHUR L. BURNETT II AND NATE READAL

Priapism refers to an erectile disorder in which an erection persists uncontrollably without sexual purpose. The general timeframe is any erection persisting beyond 4 hours. It is a medical emergency that requires prompt diagnosis and immediate treatment to prevent long-term sequelae, and a urologist should be involved early in the care of priapism patients. The disorder is a result of disturbances in the mechanisms governing erectile physiology as it relates to regulatory control of penile detumescence and initiation and maintenance of penile flaccidity. Priapism represents one of the greatest challenges in therapeutic management of erectile disorders, and although relatively rare, knowledge of proper management is required from urologists, emergency room personnel, and hematologists.

During an episode of ischemic priapism, blood fails to drain from the corporal sinusoids of the penis resulting in a prolonged, painful erection. Pain with priapism is believed to be a consequence of tissue ischemia and increased pressure within the corporal bodies that results from failure of blood egress. When prolonged, ischemic priapism leads to erectile dysfunction (ED) and prompt recognition, and diagnosis and management are necessary to minimize this risk. However, all patients should be aware that permanent ED is a possibility following a priapic episode, particularly if the duration of priapism is prolonged. Global penile fibrosis and impaired erectile mechanisms are the end result of untreated ischemic priapism and the overall rate of ED can be as high as 59% (1–3).

Priapism can be classified into two types, *ischemic (or low flow*, *venous) priapism* and *nonischemic (or high flow*, *arterial) priapism*. Ischemic priapism is the more common form, and greater than 95% of men who present with priapism will have the ischemic type (4). It is typically a result of pharmacologic use/abuse, hematologic disorders, or neurogenic causes (Table 68.1) and results in a persistent, painful erection with no cavernosal blood flow. Cavernosal blood gas is acidotic, hypoxic, and hypercarbic, and the increased pressure within the closed corporal system gives rise to a compartment syndrome that compromises cavernosal tissue oxygenation. After 24 hours of ischemic priapism, there is evidence of irreversible smooth muscle cell necrosis, destruction of vascular endothelium, and exposure of the basement membrane with adherence of thrombocytes (5).

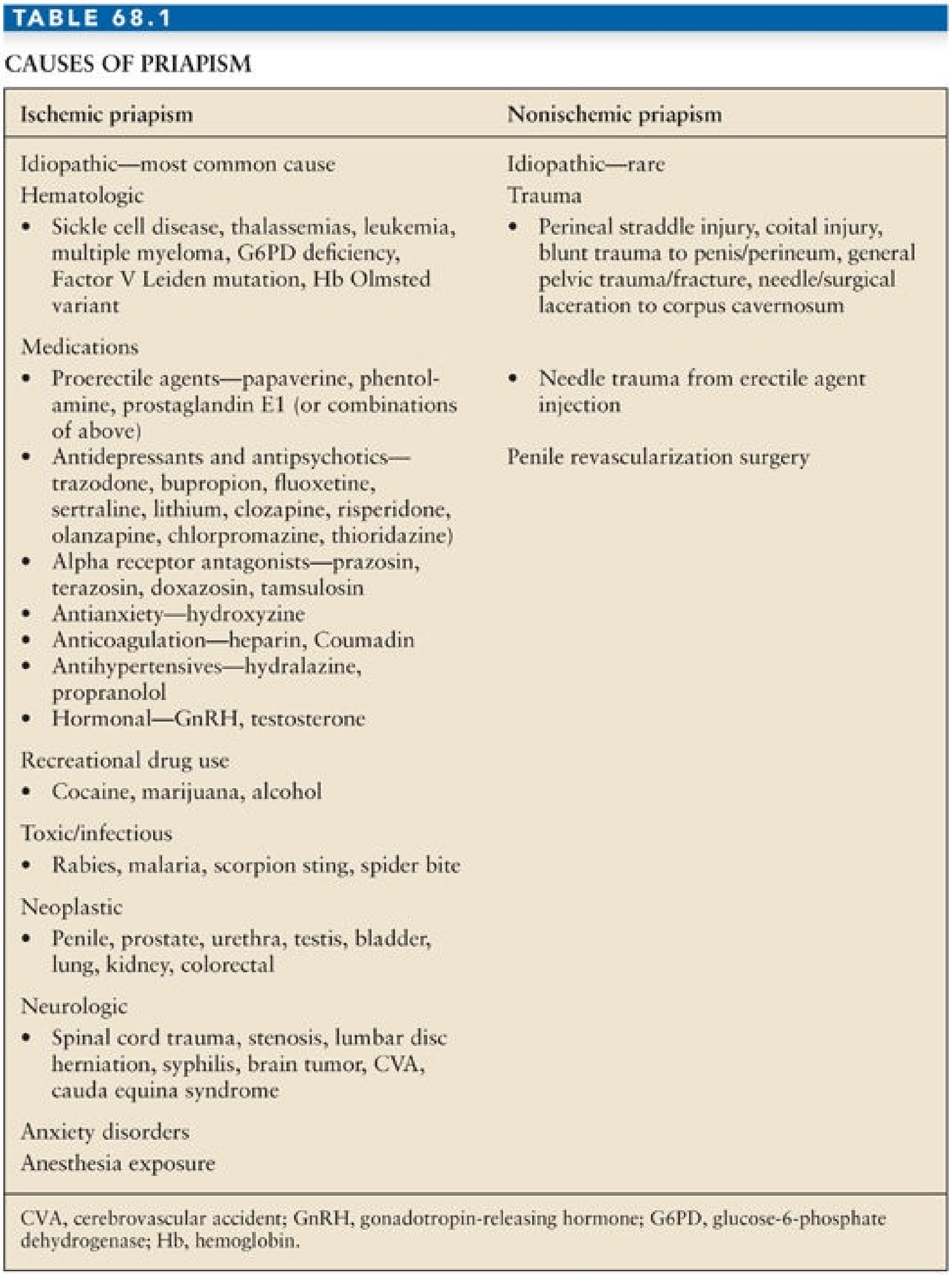

TABLE 68.1

CAUSES OF PRIAPISM

Ischemic priapism	Nonischemic priapism
Idiopathic—most common cause	Idiopathic—rare
Hematologic	Trauma
• Sickle cell disease, thalassemias, leukemia, multiple myeloma, G6PD deficiency, Factor V Leiden mutation, Hb Olmsted variant	• Perineal straddle injury, coital injury, blunt trauma to penis/perineum, general pelvic trauma/fracture, needle/surgical laceration to corpus cavernosum
Medications	
• Proerectile agents—papaverine, phentolamine, prostaglandin E1 (or combinations of above)	• Needle trauma from erectile agent injection
• Antidepressants and antipsychotics—trazodone, bupropion, fluoxetine, sertraline, lithium, clozapine, risperidone, olanzapine, chlorpromazine, thioridazine)	Penile revascularization surgery
• Alpha receptor antagonists—prazosin, terazosin, doxazosin, tamsulosin	
• Antianxiety—hydroxyzine	
• Anticoagulation—heparin, Coumadin	
• Antihypertensives—hydralazine, propranolol	
• Hormonal—GnRH, testosterone	
Recreational drug use	
• Cocaine, marijuana, alcohol	
Toxic/infectious	
• Rabies, malaria, scorpion sting, spider bite	
Neoplastic	
• Penile, prostate, urethra, testis, bladder, lung, kidney, colorectal	
Neurologic	
• Spinal cord trauma, stenosis, lumbar disc herniation, syphilis, brain tumor, CVA, cauda equina syndrome	
Anxiety disorders	
Anesthesia exposure	

CVA, cerebrovascular accident; GnRH, gonadotropin-releasing hormone; G6PD, glucose-6-phosphate dehydrogenase; Hb, hemoglobin.

Stuttering or recurrent priapism is a variant of ischemic priapism in which patients have recurrent, undesired erections characterized by prolongation and pain but a duration typically less than 3 hours (5). It is commonly encountered in sickle cell patients and episodes typically occur upon awakening from sleep and can be self-limited. These episodes are marked by intervals of detumescence and may become longer in both duration and severity until a full episode of ischemic priapism (>4 hours) results in as many as 28% of patients (6). Each episode confers a risk of fibrosis to the corpora cavernosa if not promptly recognized and treated to restore normal corporal blood flow and oxygenation.

Nonischemic priapism is a nonsexual, persistent erection that typically follows trauma to the perineum or genitalia resulting in unregulated cavernosal arterial inflow to the corporal bodies (1). The corpora are typically semirigid and nonpainful as oxygenated, arterial inflow is constant. Unlike ischemic priapism, corporal blood gas is neither hypoxic, hypercarbic, nor acidotic, and this type of priapism is not an emergency as the corporal tissue remains well oxygenated and painful symptoms are rare.

CLINICAL CHARACTERISTICS

Incidence/Prevalence

Epidemiologic data on the incidence of priapism are not abundant as such data depend on accurate recording of cases at clinics and hospitals throughout the world which does not regularly occur. Studies evaluating the incidence of priapism are typically performed in a homogenous population in which various risk factors may be present or absent, thus limiting the generalization of the results. Several such studies, however, do give some insight into the incidence of priapism in select populations. Kulmala and colleagues (7) using primary care databases determined the incidence of priapism in Finland from 1976 to 1990 to be 0.34 to 0.52 cases per 100,000 male patients per year. The incidence rates in the Netherlands and Australia were slightly higher at rates of 1.5 per 100,000 person-years and 0.84 per 100,000 person-years, respectively (2,8). New data taken from the National Emergency Department Sample database, which collects emergency department visit information from select states in the United States, has allowed a better understanding of the contemporary incidence of priapism episodes in the United States which was estimated to be 0.73 per 100,000 men per year from 2006 to 2009 (9). The incidence of hospitalization for priapism was 0.01 per 100,000 men per year, and although hospitalization for priapism is relatively rare, such an event is economically significant with an average cost of $41,909 to the health care system. In contrast, an emergency room visit for priapism has an average cost of $1,778 (9,10).

In certain select populations, however, the occurrence of priapism is known to be significantly higher. In Jamaica, where 1 in 300 children are born with sickle cell disease, the prevalence of men who have had an episode of priapism in the population is 42% and the risk of men with sickle cell disease developing an episode of priapism by the age of 20 is 89% (11). It is known that men with sickle cell disease have a lifetime risk of developing an episode of ischemic priapism of 29% to 42%, and with 20 to 25 million men worldwide who are homozygous for sickle cell disease, this represents a significant population at risk for priapism episodes (3).

Risk Factors

Priapism is associated with diverse disease states. Etiologic categories for ischemic priapism include idiopathic, which is the most common cause, neurologic conditions (multiple sclerosis, spinal cord tumor, acute spinal cord injury), hematologic dyscrasias (sickle cell disease, thalassemias, leukemia, multiple myeloma), malignancies (metastatic or local), vasoactive erectile medication therapy (prostaglandin E_1, papaverine), prescribed and recreational drug exposure (testosterone replacement, psychotropic and antidepressant medications, alcohol and illicit drugs), toxin-induced (scorpion sting or Phoneutria nigriventer spider bite) and rarely anxiety disorders, metabolic disease, or exposure to anesthesia (12,13).

Nonischemic priapism typically results from trauma to the perineum or genitalia such as a straddle injury, coital trauma, or blunt trauma such as a kick or strike. However, arteriocavernous fistulas can also result from needle lacerations occurring during penile injection therapy, direct injury during surgical procedures in the penis or perineum, or penile revascularization procedures.

PATHOPHYSIOLOGY

Ischemic priapism consists of an imbalance of vasoconstrictive and vasorelaxatory mechanisms that predispose the penis to prolonged tumescence and the development of hypoxia and acidosis. A new understanding of the molecular mechanisms leading to priapism has recently been advanced through the use of both transgenic and sickle cell disease rodent models that demonstrate multiple perturbations in these pathways contributing to the development of priapism. In endothelial nitric oxide synthase knockout and transgenic sickle cell mice, exaggerated erectile responses to cavernous nerve stimulation are observed consistent with priapism (14). The mechanism of priapism in these animals is believed to be due to chronically impaired basal endothelial nitric oxide bioavailability due to a defect in the nitric oxide signaling pathway. This results in downregulation of nitric oxide synthase activity and ultimately decreased cyclic guanosine monophosphate (cGMP) production with compensatory downregulation of phosphodiesterase type 5 (PDE5) expression in the basal state. When an erectogenic stimulus is experienced, cGMP accumulates in corporal smooth muscle causing uncontrolled dilation. With little PDE5 present to degrade the cGMP, complete, prolonged corporal body dilation ensues and priapism results (15). Adenosine overproduction has also been implicated in the development of priapism (16). Adenosine acts through the stimulation of adenylyl cyclase and synthesis of cyclic adenosine monophosphate, which activates protein kinase A and enhances smooth muscle relaxation. Increased adenosine production was present in the penis of sickle cell mice and mice that lacked adenosine deaminase, the enzyme responsible for degrading adenosine to inosine. The addition of adenosine deaminase to degrade adenosine resulted in smooth muscle contraction and resolution of priapism episodes in these animals (16).

Perturbations in the vasoconstrictive pathways that maintain penile flaccidity have also been demonstrated in sickle cell mouse penis (17). Sickle cell mouse penis demonstrates decreased Rho A activity leading to decreased ROCK2 expression and decreased total ROCK activity, all contributing to decreased basal vasoconstriction in the penis. The limited contractile ability of the corporal tissue leads to susceptibility of the tissue to excessive relaxation leading to priapism. Thus, priapism results from alterations in the vasoconstrictive and vasorelaxatory pathways of the penis that drives the organ into a state of smooth muscle hyperrelaxation and erection with little contractile reserve to counteract the process and return the penis to a flaccid state.

Ischemic priapism can also result from malignant infiltration of the penis by local or metastatic cancer, and priapism may be the presenting feature of metastatic disease to the penis in 27% of cases (18). The pathophysiology of malignant priapism can be secondary to either direct tumor infiltration of the corpora cavernosa or invasion of penile venous structures that inhibits drainage, promotes venous stasis, and leads to thrombosis within the penis (18).

DIAGNOSIS

Diagnosis and classification of priapism are based on clinical evaluation, including laboratory tests and corporal blood gas measurement via aspirated blood directly from the corpora cavernosa (12). A diagnostic and therapeutic algorithm is provided in Figure 68.1. Initial evaluation should focus on differentiation between ischemic and nonischemic priapism because this will guide both the type and urgency of further management. Patients should have a detailed history and physical examination with an emphasis on possible causative factors (see Table 68.1). Important historical factors are duration of current event, history of priapism, and baseline erectile function. A detailed medical and social history to evaluate for hematologic or neurologic conditions and review of both prescription and illicit drug use must be performed. Prolonged duration with progressively worsening penile pain favors ischemic priapism, whereas nonpainful, partial erection with preceding trauma, instrumentation, or surgery favors nonischemic priapism. Physical examination should be directed to the penis and perineum to evaluate degree of pain and rigidity while inspecting for any neurologic defect, pelvic or penile masses, or evidence of trauma. Laboratory evaluation includes a complete blood count and reticulocyte count to evaluate for anemia, infection, or other hematologic abnormalities. A sickle cell anemia screen can be used when appropriate. A urinalysis and urine toxicology screen for recent illicit, narcotic, or psychoactive drug use should be ordered.

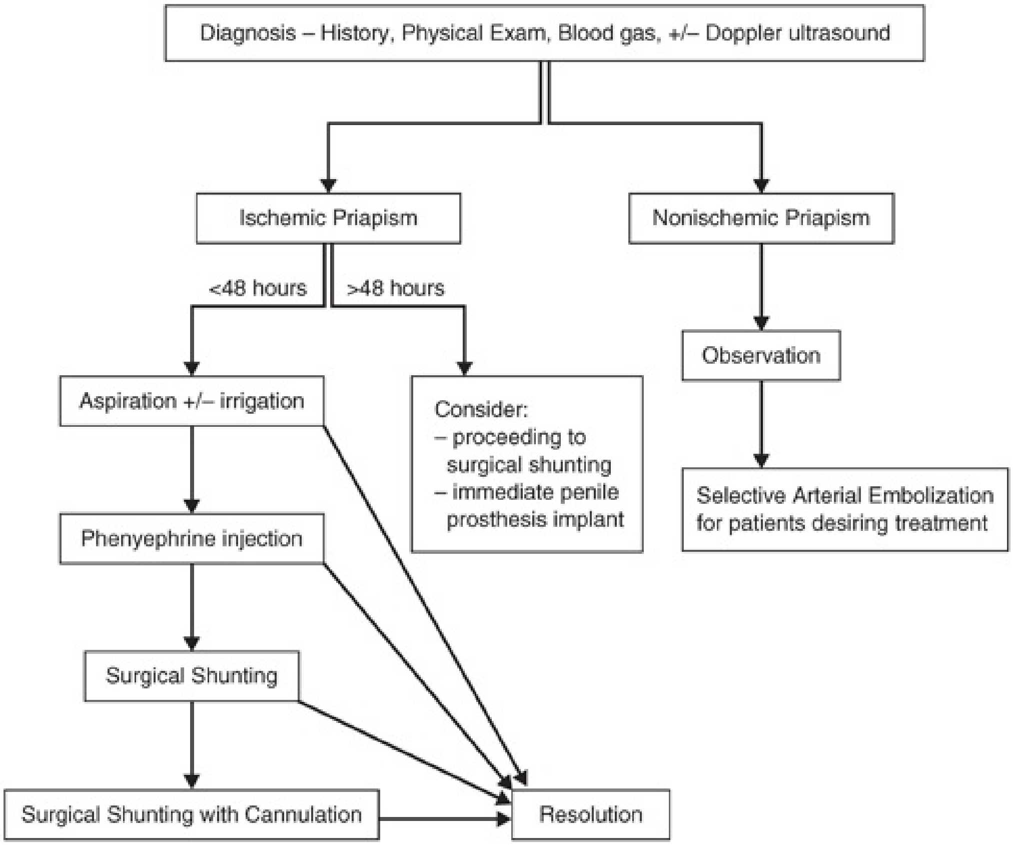
Diagnosis – History, Physical Exam, Blood gas, +/– Doppler ultrasound
Ischemic Priapism
Nonischemic Priapism
<48 hours
>48 hours
Observation
Aspiration +/– irrigation
Consider:
– proceeding to surgical shunting
– immediate penile prosthesis implant
Selective Arterial Embolization for patients desiring treatment
Phenyephrine injection
Surgical Shunting
Surgical Shunting with Cannulation
Resolution

FIGURE 68.1 Algorithm for management of priapism.

Corporal blood gas analysis will aid in determining the type of priapism. Visual inspection of the initial aspirate can be useful with deoxygenated blood of ischemic priapism having a dark, thick, “crankcase oil” appearance versus the bright red appearance of oxygenated blood in nonischemic priapism. Acidotic (pH <7.25, pO_2 <30 mm Hg, pCO_2 >60 mm Hg) penile blood gas indicates ischemic priapism, whereas a blood gas consistent with arterial blood is suggestive of nonischemic priapism. When the diagnosis is in question, color duplex Doppler ultrasound can be performed to evaluate cavernosal arterial inflow with a lack of arterial inflow being pathognomonic for ischemic priapism (12). Doppler ultrasound is also useful following interventions for priapism as it can delineate between persistent ischemia, resolved ischemia with penile edema or conversion of ischemic priapism to high-flow priapism (1).

MEDICAL THERAPY

Initial medical therapy aims to relieve penile pain and decompress the corporal bodies, thus restoring blood flow and oxygenation with the goal of minimizing tissue necrosis or injury. Ischemic priapism of >4 hours *requires* decompression of the corpora cavernosa, although one may proceed earlier in the case of severe pain. Treatment delay increases the risk of tissue injury and the risk for development of ED. There is no role for oral therapy in management of acute priapism, and initial therapy can be performed in the office setting or emergency department. A dorsal nerve block or local penile shaft block with lidocaine is typically applied. Then, a large-bore needle or 16- to 18-gauge angiocatheter is inserted directly into the penile shaft laterally until the tip has entered the corpus cavernosum. This allows for both therapeutic aspiration of old blood and injection of alpha-adrenergic agonists (5,19). Aspiration is performed with simultaneous compression of the penis below the needle insertion site until soft. Subsequent release of the compression allows the penis to fill with blood. Aspiration alone may result in detumescence in 36% of cases but has the additional benefits of relieving pressure and pain and allowing return of oxygenated blood to the corpora cavernosa even if it fails to achieve detumescence. Aspiration is followed by intracavernous injection with sympathomimetic drugs according to the American Urological Association Guidelines Panel (5). Due to potential side effects of hypertension, reflex bradycardia, or cardiac arrhythmia that may result from systemic absorption of agents, hemodynamic monitoring is recommended and alpha-adrenergic agonist therapy is contraindicated in patients with malignant or poorly controlled hypertension or patients with active monoamine oxidase inhibitor use (1). Phenylephrine, a selective alpha-1 agonist, diluted to a concentration of 100 βg per mL is preferred as it minimizes the risk of cardiovascular side effects (1). One milliliter or 100 βg is injected into the corpora cavernosa and the penis observed for 5 minutes (1).

If the penis remains rigid, then repeat aspiration and injection can be performed approximately every 5 minutes until detumescence results. This method may resolve ischemic priapism in as many as 80% of cases (12). If the penis remains erect after a reasonable duration and dose escalation of phenylephrine (1 mg total phenylephrine or >1 hour), then it is reasonable to perform another Doppler ultrasound to evaluate arterial flow in the penis or proceed to surgical shunting. Reevaluation with ultrasound may be helpful in this setting because it may differentiate between penile edema with restored corporal arterial flow versus persistent ischemic priapism. Ischemic priapism of extended duration, that is, >48 hours is unlikely to resolve with aspiration and injection and surgical shunting should be performed in a timely manner.

SURGICAL THERAPY

Surgical shunting of ischemic priapism is indicated following failure of resolution with repeated aspiration and injections or in patients who cannot tolerate injections due to conditions described in the previous section or who develop significant cardiovascular side effects from injection therapy. Surgical management of ischemic priapism involves the creation of a fistula that allows blood to drain from the corpora cavernosa to the glans penis, corpus spongiosum, or graft vein until the penile compartment syndrome has subsided. The fistula will then spontaneously close once the priapic event has resolved. Success of shunting is determined first by detumescence and then the appearance of red, oxygenated blood from the corpora cavernosa. Subsequent corporal blood gas measurements or penile duplex ultrasound can then confirm success. Surgical shunting is generally undertaken in a stepwise fashion with the least invasive procedure performed first and more invasive shunts undertaken only when preceding procedures have failed. Surgical shunt procedures are subdivided by their location on the penis and degree of invasiveness. Percutaneous distal shunt procedures (Winter, Ebbehoj, T-shunt) are typically first-line procedures that are easy to perform and have lower complication rates (1,20,21). Open distal shunts (Al-Ghorab, Burnett Corporal “snake”) typically follow percutaneous shunts and if these are unsuccessful, open proximal (corporospongiosal/Quackles) shunts may be used. If necessary, saphenous or deep/superficial dorsal vein shunting may be required, but this is rarely performed in the contemporary era.

Surgical Technique

Corporoglanular (Winter) Shunt

The Winter shunt can be performed under general or local anesthesia. If a local block is used, it should be a penile glans block to ensure adequate anesthesia to the surgical site. The tips of the rigid corpora cavernosa are palpated and then a large biopsy needle is inserted through the glans and advanced into the corpus cavernosum several times (1,20). The result is multiple core biopsy windows or fistulas between the glans and the distal end of each corporal body. Multiple fistulas are necessary to create sufficient communicating channels for blood egress and subsequent detumescence. The puncture site of the glans is closed with a figure-of-eight 3-0 chromic suture. The patient should be instructed to gently squeeze the penis every few minutes for the next 12 hours to minimize blood pooling in the penis. If a partial (>50%) or complete erection persists, the procedure may be repeated or an alternative shunt can be used. An adequate result is indicated by swelling of the glans and detumescence of the penis.

Corporoglanular (Ebbehoj and T-) Shunt

The Ebbehoj shunt procedure involves the use of a no. 11 scalpel blade passed percutaneously through the glans and into the corpus cavernosum (1,20). This results in a larger fistula between the glans and each tip of the corpus cavernosum than a Winter shunt (Fig. 68.2). The scalpel is inserted into the corpora away from the urethral meatus with care to avoid urethral injury and is then withdrawn to create an opening in the tunica albuginea between the glans and corporal bodies. A modification of the Ebbehoj shunt is the T procedure or T-shunt (1,20). A no. 10 scalpel blade is placed first vertically through the glans into the corpus cavernosum. The scalpel is then turned 90 degrees away from the urethra and withdrawn. The maneuver creates a T-shaped opening in the tunica albuginea. Both the Ebbehoj and T-shunt can be performed unilaterally or bilaterally when necessary. The T-shunt should provide a larger fistula between the corpora cavernosa and spongiosal tissue of the glans for subsequent blood egress and detumescence. The glans defect is closed with 3-0 chromic sutures.

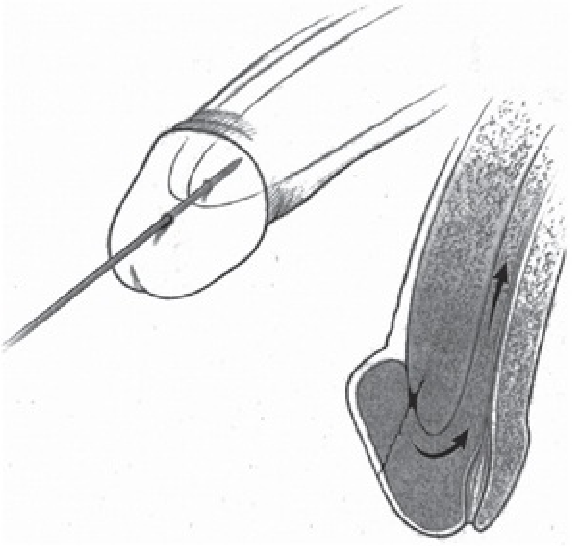

FIGURE 68.2 Corporoglanular (Winter) shunt. A needle is placed through the glans penis into the corpora cavernosa in order to make multiple core biopsy windows or fistulas between the glans and each corporal body. *Arrows* indicated return of blood flow via corpus spongiosum. (Adapted with permission from Broderick GA. Priapism. In: Wein AJ, Kavoussi LR, Novick AC, et al, eds. *Campbell-Walsh Urology*, 10th ed. Philadelphia: Saunders Elsevier, 2012:749–769. Copyright © 2012 Elsevier Inc. All rights reserved.)

Corporoglanular (Al-Ghorab) Shunt

If the previously described distal shunts are unsuccessful, then an Al-Ghorab shunt is performed (1) (Fig. 68.3). Failure of previous distal shunts is typically due to the window between the corpora cavernosa and corpus spongiosum being too small to allow blood egress from the cavernosa. An Al-Ghorab shunt is typically performed under general anesthesia and a penile glans block is additionally applied. A tourniquet is placed around the base of the penis and then a 2-cm transverse incision is made on the dorsum of the glans 1 cm distal to the coronal sulcus. A transverse incision performed in the distal penile shaft proximal to the corona is not recommended because this may severe sensory nerves to the dorsal aspect of the glans and potentially lead to distal atrophy. The tips of the corpora cavernosa are then separated from the glans and transfixed with 2-0 sutures of Vicryl and grasped with a Kocher clamp to allow traction and prevent withdrawal during detumescence. A conical segment of tunica albuginea approximately 5 mm in diameter should be sharply excised from the distal end of each corporal body. Dark blood will drain from the corporal bodies, and once detumescence occurs, reapproximation of the skin with 3-0 chromic sutures is performed. Care should be taken not to obliterate the spongy vascular space of the glans penis.

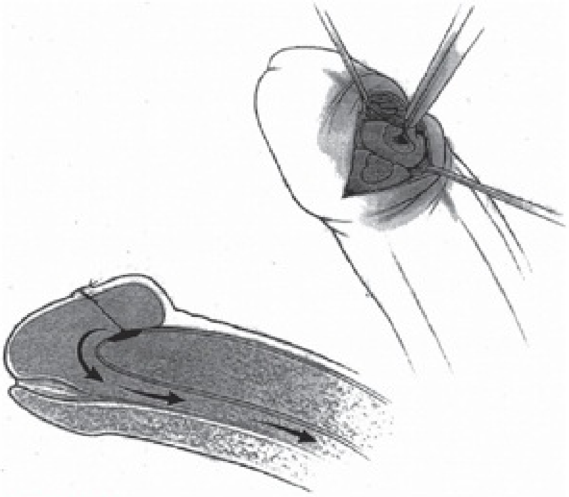

FIGURE 68.3 Corporoglanular (Al-Ghorab) shunt. An incision is made dorsally into the glans penis, and portions of the distal corpus cavernosum are excised as a vent for blood drainage. *Arrows* indicated return of blood flow via corpus spongiosum. (Adapted with permission from Broderick GA. Priapism. In: Wein AJ, Kavoussi LR, Novick AC, et al, eds. *Campbell-Walsh Urology*, 10th ed. Philadelphia: Saunders Elsevier, 2012:749–769. Copyright © 2012 Elsevier Inc. All rights reserved.)

Corporal Cannulation Techniques

Corporal cannulation has been shown to be efficacious for priapism episodes of extended durations (>36 hours). These techniques involve the addition of corporal instrumentation with sounds or dilators to the previously described distal shunt techniques to facilitate evacuation of congested, clotted blood. Brant and colleagues (22) described the use of “tunneling” in a series of seven patients in which a bilateral T-shunt procedure was performed as previously described. A 20Fr straight sound was introduced through each of the glans incisions, into the corpora, and advanced to the level of the crura. This technique creates an intracavernous “tunnel” from proximal to distal, aids in the evacuation of blood and reestablishment of cavernous blood flow.

Burnett and Pierorazio (23) described a modification of the Al-Ghorab shunt involving transglanular insertion of a size 7/8 Hegar dilator into the corporal bodies. An Al-Ghorab shunt is first performed bilaterally under general anesthesia with a penile block. Once the surgical windows into the distal corporal ends have been created a 7/8 Hegar dilator is inserted in a retrograde fashion through the tunical window and advanced proximally while applying a gentle boring motion to release congested blood (23). Following removal of the dilator, manual evacuation of blood through the channel with proximal to distal compression is performed. The glans incision is then closed with a 4-0 chromic suture. This technique corrected priapism in 8 of 10 men who had a mean priapism duration of 75 hours (24). The developers of these cannulation techniques suggest the advantages of a more complete evacuation of congested blood from the cavernosal bodies leading to increased shunt patency rates, exploitation of the favorable venous drainage of the glans and corpus spongiosum, a lower complication rate, and potential for recovery of erectile function even with priapism episodes of extremely extended durations (22–24).

Proximal Shunts

Corporospongiosal Shunts

A proximal corporospongiosal shunt is performed in rare circumstances (1,20). When distal shunts are unsuccessful or technically unachievable, then a proximal shunt may be required to reestablish blood drainage and allow for detumescence. The disadvantages of corporospongiosal shunts are low shunt patency rates, high rates of ED, and number of potential complications. To perform a Quackle (unilateral) or Sacher (bilateral) shunt, the patient is placed in lithotomy position and a perineal incision is performed. The bulbocavernous muscle is then dissected off the corpus spongiosum. A longitudinal incision or excisions of a 1 cm long ellipse of tissue is made in the spongiosal and corporal bodies in a parallel fashion so that the defects may then be sutured together. Care must be taken to avoid incising the urethra which would result in a fistula. The walls of the two incisions are then sewn together in a running fashion using a 5-0 polydioxanone suture. If detumescence is not achieved with unilateral shunt creation, then a bilateral shunt may be required and the right and left side must be separated by at least 1 cm to decreased risk of urethral stricture at the point of spongiosal to corporal communication (1).

Corporo-Saphenous Vein Shunt

The Grayhack shunt is a rarely performed procedure due to technical difficulties of the surgical approach, lack of efficacy, and complication rate (1,20). First, an incision is made at the base of the penis and the tunica albuginea of the corpus cavernosum is exposed. The femoral artery is then palpated and an incision is made at the saphenofemoral junction located approximately 3 to 4 cm below the inguinal ligament. After identifying the saphenous vein, it is mobilized for a distance of 10 cm distal to the fossa ovalis. It is then ligated distally and the index finger is used to tunnel beneath the skin to join the two incisions. The vein is passed through the tunnel without tension or torsion. An ellipse of tunica albuginea approximately 1.5 by 0.5 cm is excised and the vein is then spatulated an anastomosed to the tunica albuginea using a continuous 5-0 polydioxanone suture. A dry dressing is applied and intermittent squeezing of the penis is recommended to facilitate blood egress.

Corporo-Deep Dorsal Vein Shunt

The Barry shunt is a last resort for patients with severe priapism refractory to distal shunt maneuvers (1,20). For this shunt, a 4-cm skin incision is made at the base of the penis. The superficial or deep dorsal vein is identified with care taken to avoid injury to the dorsal artery or sensory nerves. After ligation and division, the proximal limb is spatulated ventrally and anastomosed to the corpora cavernosa in an end-to-side fashion in a tension-free manner. The penile skin is closed over the surgical site.

PENILE PROSTHESIS INSERTION

Penile prosthesis implantation plays a role in the management of acute priapism episodes when it is anticipated than penile shunting procedures will likely result in failure. The International Society for Sexual Medicine Standards Committee has established priapism episodes of greater than 72 hours duration as cases where substantial cavernous thrombosis is likely to have occurred rendering blood aspiration from the corporal bodies unfeasible (25). The touted advantages of immediate penile prosthesis implantation are a technically easier surgery and obviation of penile length loss associated with penile fibrosis which inevitably follows priapism events. Several series of "early" penile prosthesis insertion have been described, the largest of which was presented by Ralph and colleagues in 2009 (26). The study involved 50 men with prolonged priapism who failed initial therapy with aspiration, irrigation, and shunting. All men underwent successful implantation of either a malleable prosthesis (43 men) or three-piece inflatable prosthesis (7 men).

MANAGEMENT OF NONISCHEMIC PRIAPISM

Initial management of nonischemic priapism is observation due to its lack of ischemic damage and long-term consequences as well as a spontaneous resolution rate of nearly 50% to 63% (4,5). Patients seeking therapy beyond observation must be counseled on the spontaneous resolution rate that can occur even after months of observation and the potential complications of invasive treatments. Penile arteriography with selective arterial embolization is typically performed as first-line therapy with resolution rates of 75% to 100% (5,27). The use of nonpermanent materials such as autologous clot and absorbable gels is preferred over permanent materials because they have been associated with lower rates of postoperative ED (5% nonpermanent versus 39% permanent) (27). However, recent reviews have found the rates of ED following permanent embolic material use to be much lower (11.5% permanent versus 3% nonpermanent) but still not as low as nonpermanent materials (27). Second-line surgical management is arterial ligation with the use of intraoperative penile ultrasound to localize the fistula. Complications of invasive management of nonischemic priapism include ED, penile gangrene, gluteal ischemia, perineal abscess formation, and purulent cavernositis (12).

PERSPECTIVES

The most common complications of priapism and its subsequent treatment are ED, penile deformity, and possibly even genital tissue loss. The most critical factor in maintaining potency in men presenting with ischemic priapism is immediate treatment; however, it is important to recognize that these sequelae may occur despite early successful management of a priapism episode. Patients treated within 12 to 24 hours will have an increased likelihood of maintaining erectile function than those with delayed treatment. Prolonged episodes of priapism (>36 hours) and recurrent priapism are more likely to result in ED due to impaired smooth muscle function and fibrosis, and these patients will likely require penile prosthesis implantation as pharmacologic erectogenic therapy will inevitably fail. Erectile function is best preserved in the setting of nonischemic priapism. Nonischemic priapism is not a surgical emergency and is managed by observation initially with high spontaneous resolution rates. Arterial embolization may be used as treatment but carries associated risks including development of erectile dysfunction.

Proximal shunting procedures are primarily historical and rarely used in contemporary practice. Distal corporoglanular and corporospongiosal shunt procedures are the preferred surgical management techniques for ischemic priapism, and the addition of cannulation techniques have improved the efficacy of these procedures even for prolonged ischemic events. Immediate penile prosthesis insertion is a reasonable option for the treatment of prolonged or refractory ischemic priapism. Advantages of this approach include preservation of sexual function, maintenance of penile length, and the relative ease of performing the procedure before penile fibrosis ensues.

COMPLICATIONS

Complications arising due to shunt procedures are urethral damage and fistula formation, bleeding, purulent cavernositis, skin necrosis, abscess formation, and pulmonary embolism, which can occur after the Grayhack procedure. The majority of surgical shunts will close with time and it is generally thought that shunting does not in itself cause permanent ED. Failure of venous shunts to close spontaneously can result in venogenic ED due to venous leak. However, penile vascular dysfunction following shunt procedures may be a direct result of the priapism episode itself, with ischemia leading to fibrosis of the erectile tissue.

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CHAPTER 69 PENILE PROSTHESIS IMPLANTATION

ROBERT M. COWARD AND CULLEY C. CARSON

Although erectile dysfunction has been described since ancient times, adequate treatment has only been available for the last four decades. The era of implantable devices began with the development of silicone-based prosthetic materials in the late 1960s, as a result of the United States space program (1). Modern penile prosthetic devices were first developed in the early 1970s, when Small et al. (2), along with Scott et al. (3), reported the implantation of penile prosthetic devices into the corpora cavernosa to fill the cavernous space and provide a physiologically functional erection with good cosmetic results. These devices have undergone multiple redesigns and improvements between the early prosthetic devices and the currently available inflatable penile prostheses. Mechanical malfunction rates in these early devices were reported in excess of 60% of cases. Current inflatable prosthetic devices have a far improved mechanical reliability, with 81% to 94%, 68% to 89%, and 57% to 76% at 5, 10, and 15 years, respectively (4). Design changes over the past several decades have included replacement of stainless steel connectors with plastic connectors, addition of nonkinked tubing, single-design construction, Teflon cylinder input sleeves, multiple-layer cylinders, and most recently, the technologic advances in infection prevention in implant design.

The currently available devices can be divided into semirigid, mechanical, and multiple-component inflatable penile prostheses, of which there are two- and three-piece models available (Table 69.1). The semirigid rod and mechanical prostheses available today are the successors of the earliest devices designed in the 1970s. These devices, although easier to implant, have few advantages over the newer inflatable devices, as infection and mechanical malfunction rates are similar. The Genesis (Coloplast Inc, Minneapolis, Minnesota) is the currently available semirigid rod device that consists of a central metal core and a silicone elastomer rod (Fig. 69.1). The mechanical Spectra (American Medical Systems, Minnetonka, Minnesota) implant employs a spring and cable design with alternating titanium and polyethylene segments (Fig. 69.2). The Genesis is the only available malleable device with a hydrophilic coating that allows for the impregnation of antibiotics.

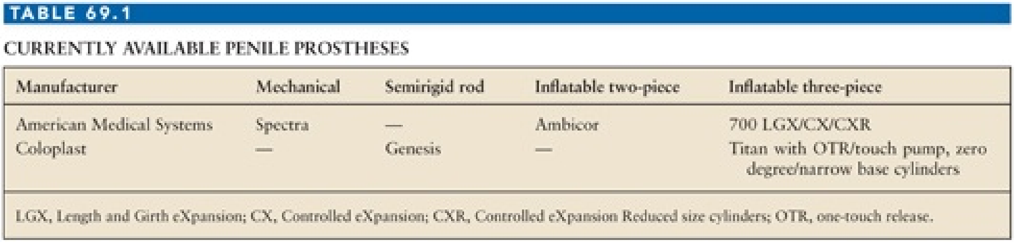

TABLE 69.1

CURRENTLY AVAILABLE PENILE PROSTHESES

Manufacturer	Mechanical	Semirigid rod	Inflatable two-piece	Inflatable three-piece
American Medical Systems	Spectra	—	Ambicor	700 LGX/CX/CXR
Coloplast	—	Genesis	—	Titan with OTR/touch pump, zero degree/narrow base cylinders

LGX, Length and Girth eXpansion; CX, Controlled eXpansion; CXR, Controlled eXpansion Reduced size cylinders; OTR, one-touch release.

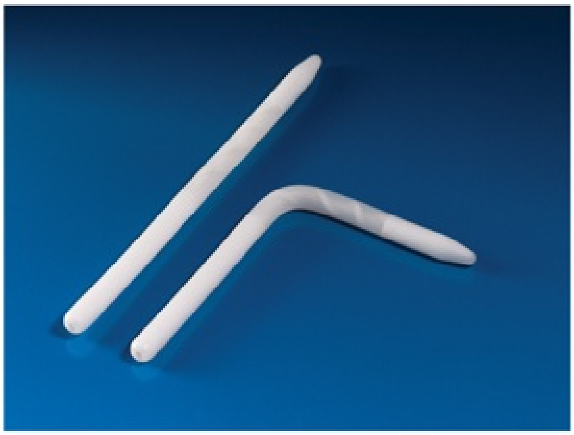

FIGURE 69.1 Coloplast Genesis semirigid rod penile prosthesis. (Genesis is a trademark of Coloplast A/S. Copyright © Coloplast Corp. Reprinted with permission. All rights reserved.)

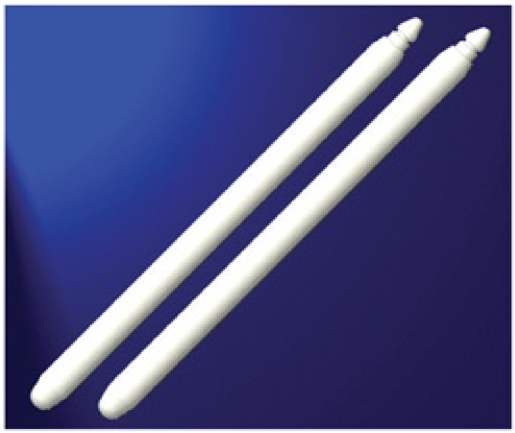

FIGURE 69.2 American Medical Systems Spectra mechanical penile prosthesis. (Spectra is a trademark of Coloplast A/S. Copyright © Coloplast Corp. Reprinted with permission. All rights reserved.)

The three-piece inflatable penile prostheses continue to be the most satisfactory prostheses once they are implanted, provided they remain functional. These prosthetic devices produce the most natural-appearing rigidity in girth and length and excellent flaccidity for optimal concealment. The three-piece inflatable penile prostheses vary in construction from three-layer silicon/Dacron/Lycra/silicone in the AMS 700 Series (American Medical Systems, Minnetonka, Minnesota) (Fig. 69.3) to a single layer of Bioflex, a polyurethane material, in the Coloplast Titan series (Coloplast Inc, Minneapolis, Minnesota) (Fig. 69.4). The Titan model is coated with polyvinylpyrrolidone, a hydrophilic material that allows absorption of an antibiotic solution of the surgeon’s choice. The preimplantation antibiotic “dip” provides a hydrophilic layer to resist bacterial adherence. The AMS 700 implants are impregnated with InhibiZone, a proprietary combination of rifampin and minocycline that is U.S. Food and Drug Administration (FDA) approved to reduce infections. Options with both available inflatable devices include standard or narrow cylinders and girth expansion and/or length elongation. Numerous trials have shown comparable efficacy, satisfaction rates, mechanical reliability, and infection rates between the two currently available inflatable devices.

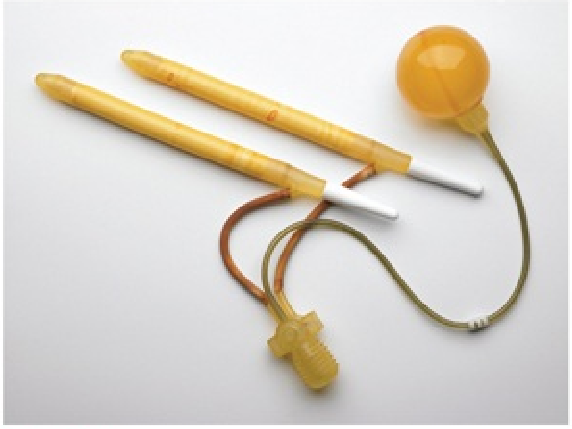

FIGURE 69.3 American Medical Systems 700 LGX three-piece inflatable penile prosthesis. (Courtesy of American Medical Systems, Inc.)

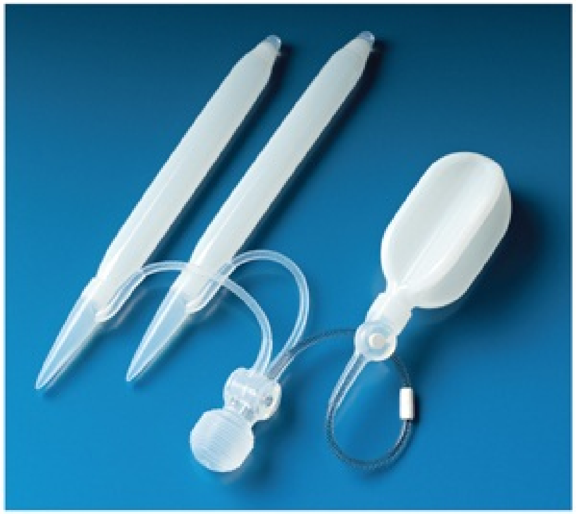

FIGURE 69.4 Coloplast Titan touch zero-degree three-piece inflatable penile prosthesis. (Courtesy of Coloplast.)

To improve ease of surgical implantation and avoid the portion of the prosthesis placed within the abdominal region, two-piece devices were designed. Because these two-piece inflatable prostheses remove the separate reservoir, additional fluid is available either by a larger scrotal pump or a combination of proximal cylinder and pump reservoir. Although these devices provide adequate penile stiffness in many patients, the limited reservoir capacity decreases the flaccidity and, in some patients, may diminish rigidity. These prostheses are especially difficult to deflate in patients with small penises and may provide inadequate rigidity in patients with longer penises. Although less optimal than three-piece devices, these two-piece implants are ideal for patients in whom reservoir placement is absolutely contraindicated. However, ectopic reservoir placement is an option for those that a three-piece device is desired, and previous surgical history precludes the ability to safely place the reservoir in the standard location. The only currently available two-piece inflatable penile prosthesis is the AMS Ambicor (American Medical Systems, Minnetonka, Minnesota) (Fig. 69.5).

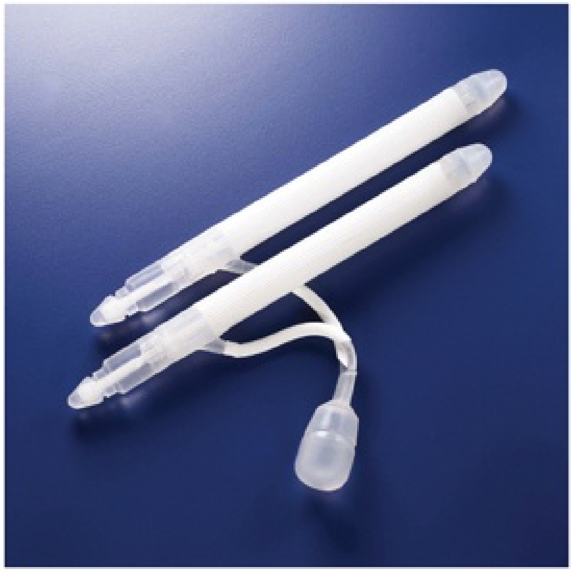

FIGURE 69.5 American Medical Systems Ambicor two-piece inflatable penile prosthesis. (Courtesy of American Medical Systems, Inc.)

DIAGNOSIS

The diagnosis of erectile dysfunction can be obtained by history. The clinician should determine whether the erectile dysfunction is situational or constant, whether the degree of dysfunction is partial or total, and also include the details of the relationship with the partner. Any coexisting conditions such as diabetes, vascular disease, smoking, medications (especially steroids, hormones, antihypertensives, or antidepressants), and use of alcohol or drugs should be identified. Physical examination should include the body habitus, hair distribution, external genitalia, and lower extremity pulses. Special attention will be directed to the testicles and penis to rule out hypogonadism and penile deformity such as Peyronie’s disease. Evaluation of the penile vasculature with penile Doppler ultrasound is useful in some patients in securing the diagnosis.

INDICATIONS FOR SURGERY

Although there are a variety of penile prosthesis designs currently available for implantation, not all patients with erectile dysfunction are candidates for penile prosthesis implantation. Penile prostheses are generally the procedure of last resort for those men failing more conservative measures such as oral phosphodiesterase type 5 (PDE5) inhibitors, vacuum erection device, urethral alprostadil, and intracavernosal injection therapy. For those men in whom penile prostheses are suggested, careful counseling before penile implant procedures will limit many of the problems with postoperative dissatisfaction. Once the discussion and demonstration of penile implant varieties has been carried out, patients can be counseled about the most appropriate penile prosthesis for their individual use. Patients may choose a specific prosthetic type based on their needs and preferences (1). Younger patients with normal manual dexterity and patients who wear form-fitting clothing, or who shower in public at athletic facilities, often choose a three-piece inflatable penile prosthesis, as the penile appearance in the flaccid position is better than other designs. For these patients, implantation of a semirigid rod penile prosthesis requires a significant lifestyle change; hence, they are better served with an inflatable device. Similarly, patients with Peyronie’s disease, secondary implantation, or significant peripheral neuropathy, such as that occurring in severe diabetes, are best served with an inflatable penile prosthesis, as intracavernosal pressures are decreased between uses, and the possibility of extrusion is diminished.

For patients in whom the convenience of inflation and deflation are not important, the risks and mechanical malfunctions may outweigh the disadvantages of a malleable penile prosthesis. Such patients as paraplegics who require external urinary collection device, those with inadequate manual dexterity, or those with significant obesity may be better served with a malleable penile prosthesis.

ALTERNATIVE THERAPY

Alternative therapy includes sexual counseling, oral pharmacotherapy with PDE5 inhibitors, vacuum erection devices, intracavernosal injection therapy, and intraurethral suppositories. Less commonly used therapies such as penile vascular (arterial or venous) surgery is discussed in Chapter 72.

SURGICAL TECHNIQUE

Surgical implantation of penile prostheses can be carried out using several surgical approaches and incisions. Semirigid and mechanical malleable prostheses can be implanted through a distal penile approach. Multiple-piece prostheses can be implanted by either the infrapubic or penoscrotal approach. Although individual surgeons have a variety of rationales for each of these approaches, there does not appear to be any clear advantage in patient satisfaction or outcome of the two approaches. Patient anatomy may dictate appropriate choice. Patients with previous abdominal surgical procedures where reservoir placement is difficult may be better served with an infrapubic approach, whereas patients with morbid obesity may be better approached through a penoscrotal incision. Two-piece devices, because there is no separate reservoir, are best implanted through a penoscrotal incision.

Infection prevention is of utmost importance during placement of a penile implant. Perioperative antibiotic treatment is critical in diminishing incidence of infection and prosthetic removal. Importantly, the recently introduced InhibiZone impregnated coating on the AMS 700 series implants and the lubricious hydrophilic coating of the Coloplast Titan series implants have reduced infection risk by threefold. Contemporary series report an infection rate of approximately 1% to 3% (5). Eid et al. (6) have described a “no-touch” technique, which takes meticulous care in preventing the device from touching the skin during implantation and has decreased the overall infection rate of virgin and revision cases to 0.46%. Other studies have shown the risk for infection in revision penile prosthesis cases to vary from 6.7% to 18.8% (5). A perioperative dosage of an intravenous antibiotic agent is recommended by the American Urological Association and should be administered within 1 to 2 hours of the incision and continued for 24 hours postoperatively. Recommended agents include an aminoglycoside plus a first-generation cephalosporin, second-generation cephalosporin, or vancomycin for prophylaxis of the most common pathogenic skin flora (5). Patients may be discharged with a continued course of oral antibiotic therapy at the surgeon’s discretion. The use of antibiotic-coated penile implants, while reducing the incidence of postoperative infection, does not preclude the need for systemic, perioperative antibiotics.

Penoscrotal Approach

Three-piece inflatable penile prostheses, as well as semirigid and two-piece prostheses, can be implanted by a transverse or vertical penoscrotal incision. This approach has distinct advantages in obese patients and is the most common approach for routine penile prosthesis implantation. The scrotum is carefully clipped, and the lower abdomen, genitals, and upper thighs are prepped. Various methods of skin prepping have been described including prolonged preoperative scrubs and most recently alcohol-based solution; however, these are surgeon-dependent. Because the penoscrotal approach requires differentiation of corpora cavernosa from the corpus spongiosum during dissection, initial placement of a Foley catheter may facilitate exposure. Prior to making the incision, a local anesthetic dorsal penile block with plain bupivacaine to decrease postoperative pain may be used (7). A penile ventral ring block is not performed, as it may distort the tissue planes of the initial dissection. The incision is placed in the upper portion of the scrotum and is usually transverse horizontal, one fingerbreadth below the penoscrotal junction. The Scott/Lone Star retractor (Lone Star Medical Products; Stafford, Texas) facilitates exposure with this incision (Fig. 69.6). Once the skin incision has been carried out, a blunt Henry sweep maneuver with an opposite spreading motion of two hooked index fingers aids the dissection, as it is carried down to the corpora cavernosa bilaterally (8). Buck's fascia is opened at the penoscrotal junction over each corpus. The corpus spongiosum is exposed. The midline spongiosal attachments of the scrotal septum may be taken down sharply for better proximal corporal exposure, and rake hooks are gently used with the Lone Star retractor to secure the bilateral testicles inferiorly, and six blunt hooks are useful to retract the lateral and superior aspects of the skin incision (Fig. 69.7).

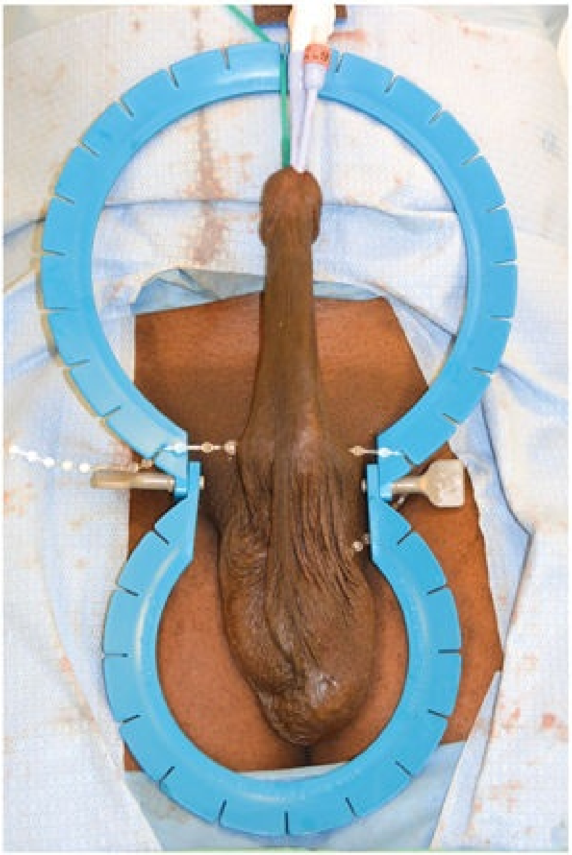

FIGURE 69.6 Initial setup for penoscrotal approach.

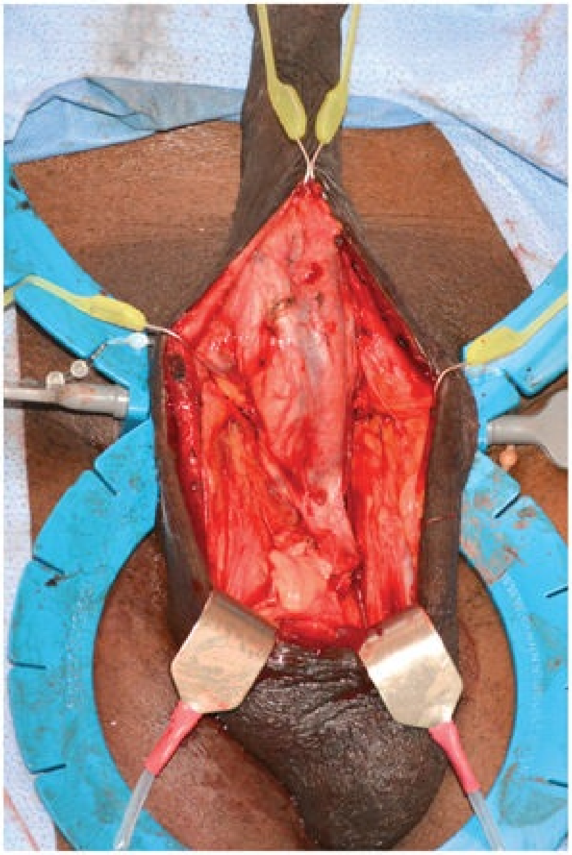

FIGURE 69.7 Corporal exposure using the Scott Lone Star Retractor.

With the shiny white tunica albuginea of the corpora cavernosa exposed, 2-0 absorbable synthetic stay sutures are placed on either side of the chosen location for each corporotomy. Care is taken that the corporotomies are symmetric in order to make the later corporal sizing measurements more straightforward. The corporal incision should be placed proximal enough so the input tubing is not palpable, avoiding the so-called “tailpipe penis” but must still allow easy exit of the input tubing and minimize cylinder to input tubing contact. The corporotomy incisions of approximately 1.5 cm are then carried out with scalpel or electrocautery between the stay sutures and the corpora cavernosa entered. Metzenbaum scissors may then be used to carefully initiate the tunneling of the corpora cavernosa, gently spreading the cavernosal tissue. Hegar, Brooks, Pratt, or Dilamezinsert dilators from size 9 to 12 may be used if necessary. In the absence of corporal fibrosis, the authors prefer a single pass with the Furlow introducer, which saves time with dilation and measurement with a single step and results in less postoperative pain (9) (Fig. 69.8). The corpora are dilated both proximally until the ischial tuberosities are encountered and distally palpating the glans penis to identify the distal most aspect of the corpora. To avoid urethral injury or corporal crossover, care is taken to maintain the urethra in a fixed position during distal dilation by bluntly grasping the glans and fossa navicularis between the thumb and index finger of the nondominant hand. The key to safe distal dilation is to direct the dilator laterally toward the ipsilateral shoulder, as it is advanced toward the glans. If concern arises for urethral injury, the corporotomy may be irrigated using a bulb syringe as a distal fluid challenge test to check for irrigant egression from the urethra. If corporal fibrosis is encountered, Rosello cavernatomes (Coloplast Inc, Minneapolis, Minnesota) may be used to dilate to size 12. In severe cases of fibrosis, the initial plane may be obtained with the careful passage of an Otis urethrotome. The advanced technique of corporal excavation (10), not further described herein, is recommended if a safe plane of dilation is unable to be achieved blindly. Once dilation has been adequately carried out bilaterally, the Furlow introducer or Dilamezinsert is used to measure the corporal length using the stay suture as a central point of reference. The proximal and distal measurements are added to identify total corporal length and obtain appropriately sized inflatable cylinders with added rear tip extenders. The measured length should be symmetric between the bilateral corpora but occasionally may differ by up to 1 cm and can be corrected with rear tip extenders. If significantly asymmetric corporal lengths are determined, the surgeon should be concerned about proximal perforation or distal crossover. To check for proximal perforation, a Brooks dilator can be placed in each proximal corpus as a “field goal test.” The dilators should symmetrically resemble a field goal without clinking together at the tips. Once the measurement has been obtained, additional interrupted sutures may be placed for later corporotomy closure if necessary prior to implantation of the cylinders. The advantage to this technique is the elimination of suture needles close to the area of the inflatable cylinder, diminishing the possibility of cylinder damage during corporotomy closure.

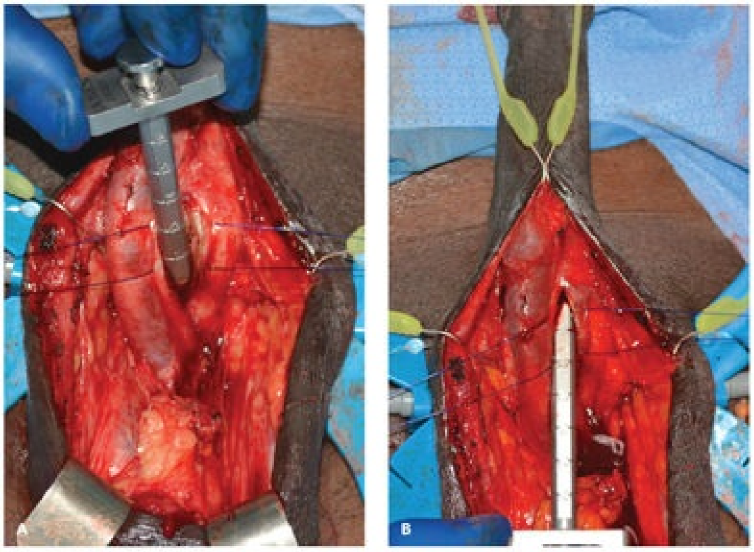

FIGURE 69.8 A single pass with the Furlow introducer for corporal dilation, proximally (A) and distally (B).

Dissection for reservoir placement is then carried out, either with a second separate infrapubic incision or more commonly is performed through the same penoscrotal incision (Fig. 69.9). The scrotal skin incision is retracted to the area of the external inguinal ring and dissection is carried out medial to the spermatic cord, superolateral to the corporotomy, and just up and over the pubis. Traditionally, the reservoir is placed on the right side but may be placed on either side at the surgeon's discretion. The bladder is completely drained before proceeding. The transversalis fascia is identified and incised sharply using Metzenbaum scissors placed firmly against the pubic tubercle. Dissection is carried out using a combination of sharp and blunt dissection. Dilation of the space is performed with blunt dissection with the index finger after incision of the transversalis fascia or with gentle spreading of a large Kelly clamp or long nasal speculum. The reservoir balloon is then positioned over the index finger and placed into the perivesical space of Retzius. Inflation of the reservoir with injectable saline is carried out with care that no backpressure is observed. If refilling of the syringe occurs, the reservoir is removed and repositioned or the reservoir pocket must be enlarged. As the reservoir is filled, the tubing should be seen slightly retracting into the space. If the tubing is increasingly moving out of the space while filling, the reservoir is likely malpositioned. After filling the reservoir, the tubing is gently pulled so the reservoir is positioned with the hub right at the fascial opening to aid explantation, if necessary in the future. The urine in the catheter tubing may be checked for hematuria to quickly confirm no injury to the bladder has occurred.

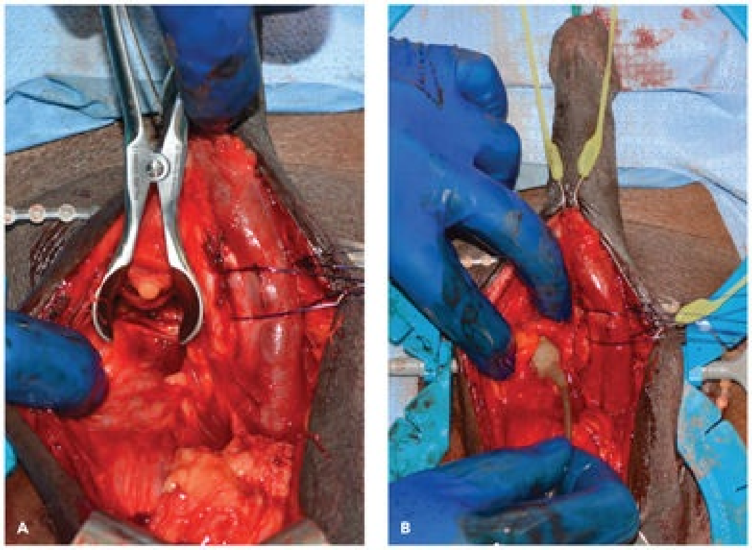

FIGURE 69.9 The reservoir space is developed with a nasal speculum (A) and the reservoir is placed through the incision in transversalis fascia medial to the spermatic cord and into the space of Retzius (B).

A recently described advancement in the surgical technique of penile implant surgery is that of ectopic reservoir placement. In ectopic reservoir placement, instead of being placed posterior to transversalis fascia in the perivesical space of Retzius, the reservoir is placed posterior to the rectus abdominis but anterior to transversalis fascia. The advantage to this technique is that it avoids the morbidity of complications resulting from traditional reservoir placement in patients who have previously had the space obliterated. Complications avoided include bowel, vascular, and bladder injuries that can occur with traditional reservoir placement after robotic-assisted laparoscopic prostatectomy, laparoscopic herniorrhaphy, or renal transplant. In addition to a separate incision, the space can be created from the penoscrotal approach by passing a long clamp such as a lung grasping forceps, ring forceps, or long nasal speculum into the medial leaflet of the external inguinal ring in a cephalad direction with gentle spreading of the clamp, developing the submuscular space posterior to the rectus (11). Early results of this technique support its safety and efficacy, with a complication rate attributable to the ectopic reservoir placement to a total less than 3%, including herniation, palpability requiring revision, and autoinflation (12).

Once the reservoir is placed, the implant is prepared on the back table by removing all air bubbles and then brought into the field. At this time, surgical gloves may be changed and an additional drape may be placed just beneath the incision and over the patient’s lap to minimize contact of the device with the working field. Rear tip extenders of various sizes are available to be placed on the proximal cylinder end to adjust length. The cylinders are positioned within the dilated corpora cavernosa using the Furlow introducer and Keith needle; the cylinders are pulled into position by the suture attached to the tip of each cylinder (Fig. 69.10). Once positioned, it is essential to visualize the cylinder in the corpus cavernosum to ensure that it is flat, there is no kinking, and complete proximal and distal seating has taken place. Closure of the corpora cavernosa is carried out using the preplaced sutures while maintaining distal traction on the cylinder suture to ensure adequate seating. Following placement of the cylinders and closure of the corporotomy incisions, cylinder inflation can be tested, if necessary, to identify any abnormalities in position, curvature, or other problems with the cylinders. By connecting a syringe of sterile injectable saline to the open end of the pump’s input tubing, manual inflation of the device is performed to check the proper position of the cylinders.

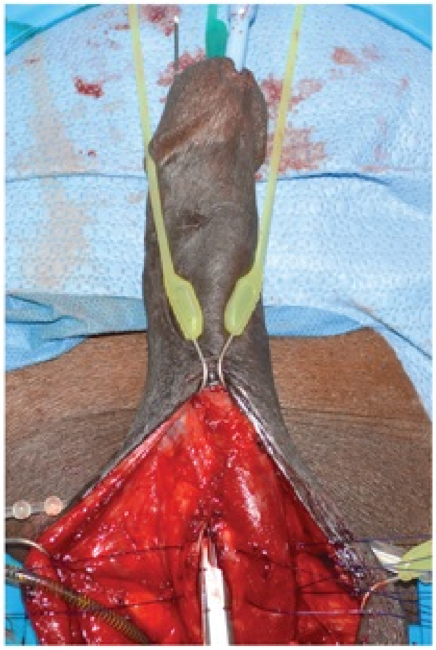

FIGURE 69.10 The Furlow introducer is used to deploy the Keith needle through the glans in order to pull the cylinder into place distally by its attached suture.

The pump is positioned in the most dependent portion of the scrotum. The pump may be placed inferiorly between the testicles or more commonly is placed within a subdartos pouch. For creation of a subdartos pouch, a small incision is made in the inferior scrotal midline dartos fascia between two Allis clamps, and the pouch is created using gentle spreading of a long nasal speculum or ring forceps. Alternatively, the most dependent part of the scrotum may be everted up through the penoscrotal incision with the index and middle fingers, and the dartos may be gently spread off of the underlying skin with a sponge (Fig. 69.11). The pump is then positioned into the pouch and may be secured using a Babcock clamp, whereas an interrupted or purse-string 3-0 absorbable suture is used to secure the pump and tubing down into its pouch.

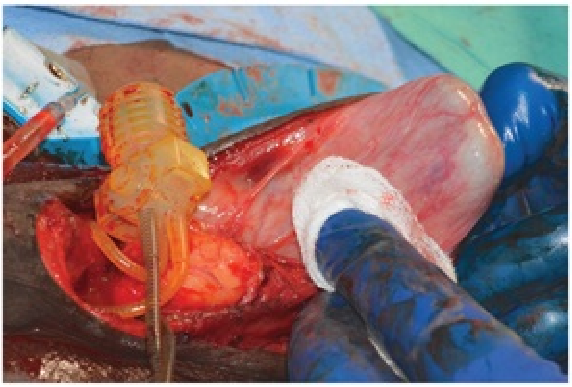

FIGURE 69.11 The most dependent part of the scrotum is everted up through the incision and the dartos is gently spread off of the underlying skin with a sponge to create a subdartos pouch for the pump.

After pump placement, the tubing between the reservoir and pump is then connected. The tubing is tailored to eliminate excessive length but to allow for adequate pump positioning prior to making the connection. Shodded clamps are used to compress the tubing, and the ends of the tubing, once tailored, are flushed with saline to eliminate bubbles, small particles, and blood clots. Tubing connection is then carried out using quick connectors, snap-on connectors, or suture tie plastic connectors. In revision prosthesis cases, in which a residual tubing segment is connected to a new device piece, suture tie plastic connectors must be used. After the tubing is connected, the adequacy of the connection is tested by gently pulling on the connectors. All shodded clamps are removed and the device is cycled multiple times to ensure adequate location, placement, and penile rigidity (Fig. 69.12).

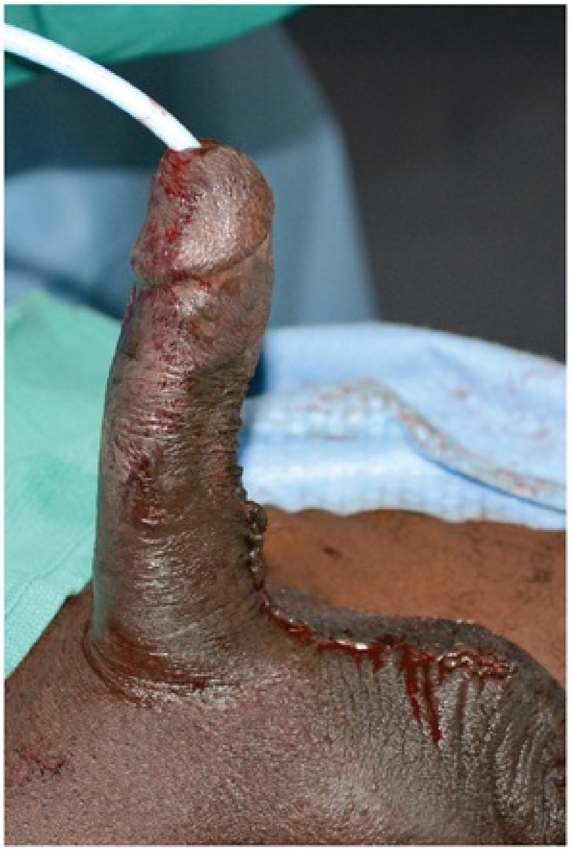

FIGURE 69.12 The implanted device is tested.

In patients with Peyronie’s disease, mild curvature is commonly overcome with the inflatable penile prosthesis. If the device is test inflated after implantation and significant residual curvature is encountered, however, several options are available. The most commonly used and effective technique is penile modeling (13). During modeling, the cylinders are fully inflated and the cylinder exit tubing is clamped with shodded clamps to prevent excessive backpressure to the pump. Two fingers are firmly pressed on the corporotomy sites by the assistant to prevent blow-out of the cylinder through the corporotomies during modeling. The shaft is then forcibly bent in the direction opposite the curvature for approximately 90 seconds to rupture the plaque, and this maneuver may be repeated several times until desired results are achieved. In difficult cases of severe residual curvature, other options for straightening at this juncture include concomitant tunical plication, relaxing tunical incisions, or plaque incision and grafting (13). If anticipated preoperatively, the case may begin with an artificial erection of injectable saline for characterization of the curvature, and a vertical incision should be used, which can be extended ventrally onto the shaft for placement of the plication sutures prior to implantation of the device (14).

For closure, a deep dartos layer with 3-0 absorbable sutures called a Lentz stitch is helpful to keep the tubing maintained in a posterior location in the scrotum so it is not palpable beneath the incision. Suction drains may be used at the surgeon’s discretion. A formal dartos layer is then reapproximated with 3-0 absorbable suture, and finally, skin closure is carried out with a running horizontal mattress suture in the standard fashion. In men with a penoscrotal skin web, the horizontal skin incision can be closed in a vertical midline Heineke-Mikulicz fashion to enhance functional penile length. Alternatively, in the case of a scrotal web, a ventral phalloplasty may be performed as part of the initial incision. As described by Miranda-Sousa et al. (15), a checkmark-shaped incision in an asymmetric V shape, longer in the inferior segment, may be made on each side of the web to excise a diamond-shaped piece of skin at the start of the case, with a vertical midline closure. After closure, a dressing of a topical skin adhesive or antibiotic ointment is applied. A “mummy wrap” may be applied with 4-inch Kerlix gauze in a figure of eight fashion, whereas the pump is maintained in its dependent position during the wrap (8).

The penile prosthesis remains deflated for 4 weeks while healing occurs. Prior to activation, the patient is advised to retract the pump into his scrotum on a daily basis and tight underwear and athletic supports are avoided to maintain pump position. A return office visit for activation of the device is carried out once discomfort has resolved. Patients are advised to inflate and deflate the device on a daily basis for 4 weeks to allow tissue expansion around the prosthesis. Most patients can then begin use of their device 4 to 6 weeks after implantation.

Infrapubic Approach

The infrapubic approach allows better visualization of the reservoir placement than the penoscrotal approach. However, because of the proximity of the dorsal neurovascular bundle in the infrapubic approach, injury is possible, resulting in decreased distal penile sensation in some patients. The infrapubic approach is usually carried out with a horizontal incision approximately one fingerbreadth below the pubic symphysis, allowing implantation with an easily concealed incision once the pubic hair regrows. In patients with significant obesity or a previous midline incision, however, a midline incision carried out just to the base of the penis facilitates exposure of the corpora cavernosa and improves the ability for corporal dilation. After division of Colles and Scarpa fascia, the dissection is continued to the rectus fascia. The rectus fascia is incised horizontally and dissected cephalad for approximately 2 to 3 cm. A midline separation of the rectus muscles is carried out using sharp and blunt dissection. A pouch is created bluntly beneath the rectus muscles to comfortably insert the inflatable reservoir without compression. The previously described methods of reservoir placement in the section for the penoscrotal approach, including ectopic reservoir placement, may also be used during an infrapubic approach.

Dissection is then carried out over the corpora cavernosa. Sharp and blunt dissection is begun on either side of the fundiform ligament identifying the dorsal neurovascular bundle. Note that the dorsal nerves of the penis lay approximately 2 to 3 mm lateral to the deep dorsal vein. A directly visualized dorsal nerve block with plain bupivacaine may be performed at this time if desired to decrease postoperative pain (7). Once Buck’s fascia has been dissected free from the tunica albuginea, the shiny white tunica albuginea is fixed with traction stay sutures of 2-0 absorbable, synthetic suture. Incision, dilation, and sizing of the corpora cavernosa are similar to that described previously for the penoscrotal approach. Cylinder placement follows next as previously described earlier in a similar manner as with the penoscrotal approach.

A finger is then placed in the most dependent portion of the scrotum lateral to the testicle on the right or left side. The finger is then pushed to the area of the external inguinal ring and any adipose tissue in this area is dissected free to expose the dartos fascia. Following development of the subdartos pouch for the pump, the pump is positioned in the most dependent portion of the scrotum and temporarily fixed into position using a Babcock clamp. The inflatable reservoir is then placed in the previously constructed position and filled with an appropriate volume of sterile injectable saline. Before connection, it is important to release pressure on the filling syringe and determine if any backfilling is seen. The tubing is tailored to the appropriate length and connected in a similar manner as previously described for the penoscrotal approach.

Suction drains may be used at the surgeon’s discretion. Following test inflation and deflation, thorough irrigation with antibiotic solution is carried out and the rectus fascia closed with interrupted absorbable synthetic sutures if this approach was used for reservoir placement. The wound is then closed in the standard fashion with two layers of subcutaneous tissue and a subcuticular skin suture. A dressing is applied as previously described, a Foley catheter placed if necessary, and a 10-pound sandbag is placed over the incision during the immediate recovery.

Postoperatively, patients are instructed to maintain their penis in a Sutherland position for 4 to 6 weeks. Tight underwear and athletic supporters are not used in an effort to maintain the pump in its most dependent position.

Distal Penile (Subcoronal) Approach

A distal penile (subcoronal) approach is usually the best approach for insertion of a semirigid or mechanical penile prosthesis. This incision heals well, allows complete corporal dilation, and facilitates rod placement. A local anesthetic dorsal penile and ring block with plain bupivacaine is performed to decrease postoperative pain (7). After placement of a Foley urethral catheter, a dorsal circumcoronal incision is carried out over 180 degrees of the subcoronal region of the penis along the previous circumcision scar. Dissection is carried down to the layer of Buck’s fascia, taking care to avoid the dorsal penile nerves, which course dorsally within Buck’s fascia just lateral to the visible dorsal vein. After Buck’s fascia is identified, stay sutures are applied to the two corpora through the tunica albuginea lateral to the penile nerves, and longitudinal incisions are made. These longitudinal incisions can be extended proximally as much as is necessary for dilation and cylinder insertion. The corporal dissection is begun with Metzenbaum scissors to establish a track in the corporal tissue. Dilation then follows with Hegar, Brooks, or Dilamezinsert dilators to 9 to 11 cm depending on required cylinder girth. A single pass with the Furlow provides adequate dilation in the absence of corporal fibrosis, saves time, and results in less postoperative pain (9). Once the corpora are sized using a Furlow introducer or other dilator, the cylinders can be placed. A small vein retractor can be used to facilitate placement of the distal end of the cylinder. The corporotomy is closed with 2-0 absorbable, synthetic sutures. A noncompression dressing is applied.

OUTCOMES

Complications

Despite careful counseling, many patients enter penile prosthesis procedures with expectations that cannot be met by penile prosthesis surgery. Complaints about decreased penile length compared with preimplant state, decreased penile sensation, “coolness” of the penis and glans penis, and chronic pain, as well as partner dissatisfaction, are among the complaints patients may voice despite adequate surgical implantation and satisfactory mechanical functioning. Fortunately, these complaints are unusual and more than 90% of patients report satisfaction with their prostheses (4). Many patients who are dissatisfied with their penile prostheses will benefit from sexual counseling or continued counseling assistance from the implanting surgeon to be sure that they are able to operate the device satisfactorily and understand its use.

Most patients’ dissatisfaction results from difficulty with operation of the device and unrealistic expectations. Preoperative discussions with patients should include the concept that penile prostheses do not create normal erections but only support the penis for sexual activity. Penile prosthesis surgery brings about the ability to resume sexual functioning and vaginal penetration, but decreased penile sensation, length, and engorgement may result. Patients should also be advised that a penile prosthesis will not improve libido or ejaculation. Patients frequently report delayed or difficult ejaculation initially following penile prosthesis surgery. This delay is primarily a result of inadequate preparation, stimulation, and psychological adjustment to the prosthesis. Most patients require 3 to 6 months of prosthesis use with careful attention to presexual stimulation before ejaculation routinely returns to preoperative levels. Because the prosthesis neither improves nor detracts from preoperative ejaculatory ability, patients must be counseled regarding their preoperative ejaculatory ability before prosthesis placement.

The most worrisome postoperative complication is infection, which occurs in fewer than 10% of all patients (5). Perioperative prosthetic infections can, however, occur at any time in the postoperative period in patients with penile or other prosthetic devices. Patients continue to be at risk for hematogenous seeded infections from gastrointestinal, dental, or urologic manipulations as well as remote infections. Patients must be counseled to request antibiotic coverage if remote infections occur. Gram-positive organisms such as *Staphylococcus epidermidis* cause most periprosthetic infections, but gram-negative organisms such as *Escherichia coli* and *Pseudomonas* are also common culprits. Severe gangrenous infections with a combination of gram-negative and anaerobic organisms have also been identified and frequently result in significant disability and tissue loss. Patients at increased risk for perioperative infections include diabetics, patients undergoing penile straightening procedures or circumcision with prosthetic implantation, patients with urinary tract bacterial colonization, and immunocompromised patients, such as posttransplant patients. Spinal cord injury patients have also been reported to have a specially increased risk of infections, with rates reported as high as 15%.

Appropriate treatment of prosthetic infections requires early and immediate identification with institution of parenteral antibiotic therapy and early prosthesis removal (16). Conservative treatment would dictate a healing period of 3 to 6 months followed by repeat prosthesis implantation. Better long-term results with no additional morbidity can be achieved with the prosthesis immediate salvage technique reported by Mulcahy (17). This technique—which requires removal of the infected implant and two rounds of vigorous irrigation using solutions of antibiotics, povidone iodine, and hydrogen peroxide prior to immediate replacement with a new device—is successful in more than 75% of infected prostheses (16).

The most common complication of penile prosthesis function is mechanical malfunction. After a decline from early rates as high as 61%, the current inflatable prosthetic devices have mechanical reliability rates of 81% to 94%, 68% to 89%, and 57% to 76% at 5, 10, and 15 years, respectively (4). Aneurismal dilation of inflatable cylinders, reservoir leakage, and pump malfunction have been limited by device modifications. Fluid leak, however, continues to be a problem for many inflatable penile prostheses. These mechanical malfunctions require replacement of the leaking portion of the inflatable portion of the prosthesis. If nonfunctioning prosthesis has been in place more than 2 years, however, it is usual practice to replace the entire device to reduce further mechanical malfunction.

Semirigid rod penile prostheses are associated with fewer mechanical problems; the most common complication associated with these prostheses is cylinder erosion through skin or urethra. Prosthesis fracture or breakage has been reported, and patients may return 6 to 8 years post-implantation with complaints of decreased rigidity of their semirigid rod, indicating fracture of central prosthetic cylinder wires. These wire fractures cannot usually be appreciated radiographically unless the prosthesis is put on stretch once it has been explanted. Replacement of these devices is indicated when patients note decreased rigidity. Prosthesis extrusion or erosion is most common in diabetics and spinal cord injury patients, especially those requiring urinary management with catheter placement or of condom catheter collection devices.

Extrusion can also occur beneath the penile skin distally from vigorous dilation or remotely from trauma or repeated use. These extrusions are characterized by distal penile pain with use.

Correction can be carried out with the use of a patch graft, but a better approach is rerouting with no grafting material. Rerouting is associated with less infection and pain and a reduced recurrence rate.

Results

Long-term function and use have been confirmed in studies of patients with implants as long as 10 years (18). Overall satisfaction rates from long-term series of three-piece inflatable penile prostheses range from 92% to 100% among patients and 91% to 95% among partners. In addition, 86% to 88% of patients would recommend the prosthesis to a friend (4). Studies have confirmed that patient satisfaction among men with penile implants is greater than any other erectile dysfunction (ED) treatment modality (1).

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CHAPTER 70 PENILE VASCULAR SURGERY

JACK M. ZUCKERMAN AND KURT MCCAMMON

Erectile dysfunction (ED) negatively impacts quality of life for a diverse spectrum of the worldwide population. In the United States, its prevalence in men 40 to 70 years of age has been estimated around 50% (1), and the incidence of ED increases with each decade of life (2). Many patients with ED have a variety of risk factors, including atherosclerotic arterial disease, diabetes mellitus, hypertension, and tobacco abuse leading to arteriogenic or neurogenic ED. Not surprisingly, coronary artery disease (CAD) has been shown to have a direct correlation with pudendal artery stenosis leading to arterial insufficiency and ED (3).

In the aging male, ED most commonly is a manifestation of the patients overall health, specifically vascular health. Sustaining a rigid erection requires adequate perfusion of the corpora cavernosa through a robust arterial inflow as well as increased resistance to venous outflow. Systemic risk factors affecting either arterial inflow or venous outflow, therefore, can be expected to negatively impact erectile function. Endothelial dysfunction commonly affects both pudendal and coronary arteries (4). For patients without known vascular disease, a new ED diagnosis may represent a harbinger of future adverse events, such as myocardial infarction or cerebrovascular insult. Montorsi and colleagues identified a significant lag of 39 months between presentation of ED and CAD, suggesting that the smaller penile vessels are affected by arterial disease prior to the larger caliber coronary arteries (5).

Although common in the elderly population, young and middle-aged men (age teens to 40 or 50 years) present less often for evaluation of ED. Although practitioners now commonly consider vascular disease in the older patient with ED, younger men are more likely to be diagnosed with a psychogenic etiology for their impotence. Ironically, as these young men are often otherwise healthy, it is this very population who may be found to have isolated vascular lesions amenable to curative surgical intervention.

Traumatic injuries are a less frequent etiology of ED. Pelvic fractures, which are the primary traumatic injury associated with ED, are relatively rare and occur in less than 10% of blunt trauma (6,7). Pelvic fractures most often result from a high-energy impact, which has implications for nearby genitourinary organs, primarily bladder and urethra. Pelvic fracture urethral injuries (PFUIs) with disruption of the membranous urethra have been reported in up to 10%, and bladder injuries occur slightly more frequently (6–9). Despite the polytrauma setting in which most pelvic fractures occur, improvements in trauma resuscitation have resulted in dramatically reduced mortality for these patients. Demetriades and colleagues described a large series of traumatic pelvic fractures and found an overall mortality rate of only 13.6%, of which less than 1% died as a direct result of the pelvic fracture (6). These improvements in survivability subsequently result in a larger portion of these patients suffering from chronic problems related to their injuries, including sexual dysfunction. This is particularly problematic for the young adult patient at the beginning of his sexual life.

The distal internal pudendal, common penile, and cavernosal arteries are also susceptible to blunt trauma less obvious than an injury that causes a pelvic fracture. Given their location within Alcock canal and proximity to the ischiopubic rami, these arteries can be injured simply bicycle riding or by a straddle injury, such as perineal trauma attempting advanced “rail tricks” on a skateboard or snowboard (10).

Similar to focal arterial insufficiency, ED secondary to veno-occlusive disease (venogenic ED [VED]) is an etiology found in a portion of younger patients and may be amenable to surgical intervention. Failure of full expansion of the sinus spaces secondary to diffuse smooth muscle dysfunction or replacement with fibrous tissue accounts for much of the identified veno-occlusive dysfunction. Additionally, alterations within the tunica albuginea, specifically atrophy of the collagen composition leading to tissue laxity, have been suggested to account for a portion of patients with diffuse veno-occlusive dysfunction (11). These etiologies are thought to occur primarily in older men, especially those with other associated conditions, such as having undergone radical prostatectomy or pelvic radiation (12,13). However, in younger patients, focal defects in the integrity of the tunica albuginea or congenital abnormal venous channels may also result in VED. These patients often present with primary ED, present since initial sexual encounters. Penile trauma, surgery for priapism or Peyronie disease, and previous endoscopic incisions of urethral strictures can all lead to defects in the corporal veno-occlusive mechanism (14).

In this chapter, we will discuss the vascular surgical management for ED in patients with focal anatomic defects in either arterial inflow or venous outflow. We review the diagnosis, patient selection, evaluation and treatment outcomes, and complications.

PHYSIOLOGY OF ERECTILE FUNCTION

Penile erection begins with autonomic cavernosal nerve stimulation (15). Nitric oxide (NO) synthase, an enzyme in lacunar space vascular endothelial cells and autonomic cavernosal nerve endings, facilitates the synthesis of NO from molecular oxygen and L-arginine. During sexual stimulation, NO activates guanylyl cyclase, an enzyme that facilitates the synthesis of the second messenger, cyclic guanosine monophosphate (cGMP) from guanosine triphosphate. The elevated concentrations of cGMP result in lowered intracellular calcium, thus promoting penile smooth muscle relaxation. Biologic consequences of NO-cGMP relaxation include increased arterial blood inflow, engorgement of the lacunar spaces, lengthening and enlargement of the corporal erectile tissue within the constrained tunica albuginea, and eventual subtunical venule occlusion with increased penile venous outflow resistance and corporal veno-occlusive function (16).

DIAGNOSIS

Younger men with ED and the absence of other vascular risk factors represent the ideal patient population to evaluate for vasculogenic and/or VED. Evaluation should begin with a comprehensive history and physical examination, specifically a detailed past urologic history. Common risk factors for ED should be ruled out, such as medication side effects, cardiovascular disease, diabetes, tobacco use, and psychological disorders. History may reveal a history of pelvic fracture or penile/perineal trauma. Distance bicycle riding is a known risk factor for pudendal arterial injury, which may lead to arteriogenic ED and should be assessed (17). Patients with congenital veno-occlusive dysfunction may complain of complete lifelong ED or rapid loss of erection. Any past genitourinary procedures, especially penile surgeries must be documented. A limited endocrine evaluation should be obtained, including a morning testosterone.

Patients suspected of either arteriogenic or VED should be offered a progressive diagnostic evaluation (Fig. 70.1). Penile color duplex Doppler ultrasonography is the best initial study. This test allows a rapid assessment of both penile arterial inflow and veno-occlusion. Additionally, it allows direct observation of the erectile response to intracavernosal injection of a vasodilating agent. Patients are administered 20 μg of prostaglandin E_1, and the duplex is performed 10 minutes following administration. We determine patients to have arterial insufficiency if their peak systolic velocities for the dorsal or cavernosal arteries are less than 30 cm per second (18,19). Prolonged systolic rise time, especially greater than 100 milliseconds, is also associated with atherosclerotic ED.

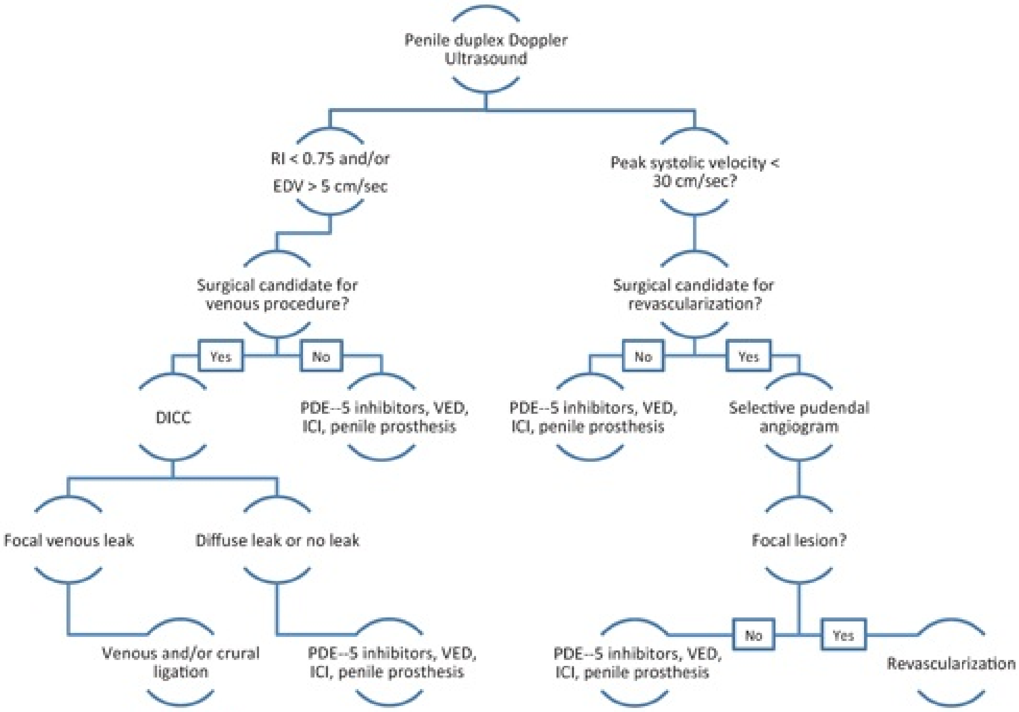
Penile duplex Doppler Ultrasound
RI < 0.75 and/or EDV > 5 cm/sec
Peak systolic velocity < 30 cm/sec?
Surgical candidate for venous procedure?
Surgical candidate for revascularization?
Yes
No
No
Yes
DICC
PDE--5 inhibitors, VED, ICI, penile prosthesis
PDE--5 inhibitors, VED, ICI, penile prosthesis
Selective pudendal angiogram
Focal venous leak
Diffuse leak or no leak
Focal lesion?
Venous and/or crural ligation
PDE--5 inhibitors, VED, ICI, penile prosthesis
No
Yes
PDE--5 inhibitors, VED, ICI, penile prosthesis
Revascularization

FIGURE 70.1 Diagnostic algorithm for arterial or venogenic erectile dysfunction (*VED*). *DICC*, direct infusion cavernosometry and cavernosography; *EDV*, end diastolic velocity; *ICI*, intra-cavernosal injection; *RI*, resistive index; *PDE5*, phosphodiesterase type 5.

In patients with normal arterial inflow, venous leak is ruled out if the resistive index is >0.9 and/or the end-diastolic velocity approaches zero (less than 5 cm per second). Venous leak is suggested when the resistive index is <0.75 and the dorsal vein velocity is >10 cm per second (18). Finally, during the penile duplex ultrasound, the deep inferior epigastric arteries (DIEA) are also evaluated, giving us important information about vessel size, blood flow within the vessel, and where the vessel begins its intramuscular course in the event these vessels are used for arterial bypass surgery. During the entire procedure, it is crucial to provide a private, quiet, and comfortable environment for testing because patient anxiety will effectively counteract the dilatory effect of the injected agent and reduce the reliability of the results. Those patients not achieving a sufficient erection following injection of the vasodilating agent, whether secondary to anxiety and sympathetic discharge or concomitant arterial pathology, cannot be adequately evaluated for veno-occlusive dysfunction. Penile duplex interpreted in that scenario have been shown more commonly to falsely diagnose venous leak (20). Conversely, patients achieving a normal rigid erection following administration of a vasoactive intracavernosal agent lessen the likelihood of significant arterial or venous pathology.

If arterial insufficiency is suggested, patients being considered for surgical intervention should undergo a selective internal pudendal angiogram to evaluate for pudendal or common penile artery occlusion. We also evaluate the inferior epigastric arteries during this angiogram because these will serve as the donor vessels during any future revascularization. More recently, we have obtained computerized tomography (CT) angiography to help clarify the course of the deep inferior epigastric artery (DIEA). We have found this especially helpful in those patients who show an early entry of the DIEA into the rectus muscle. Patients in whom venogenic impotence is suggested on penile duplex do not require a pudendal angiogram.

Direct infusion cavernosometry and cavernosography (DICC) are the definitive tests for diagnosing VED and identifying sites of leakage. We perform this study in all patients being considered for venous surgery. Small gauge needles are placed into each of the corpora cavernosa. One is connected to a pressure transducer, and the other is connected to an infusion pump with metered delivery rates of heparinized saline. After injection of a vasodilating agent, the need for a flow rate of >20 mL per minute of saline to maintain a rigid erection at an intracorporeal pressure of at least 90 mm Hg is indicative of corporal veno-occlusive dysfunction. A maintenance flow rate between 10 and 20 mL per minute is considered borderline for venous leakage. Excessively high maintenance flows (>50 mL per minute) usually indicate massive venous runoff, and these patients do not do well with veno-occlusive surgery (21). Pressure decay of more than 30 mm Hg within 30 seconds is also suggestive of venous leak. Isosmotic contrast material is then infused into the corpora at the previously defined maintenance flow rate from cavernosometry and then anteroposterior and oblique radiographs of the penis are taken. The most common sites of venous leakage seen in patients with veno-occlusive dysfunction are the deep dorsal vein, the cavernosal veins, and the circumflex veins at the base of the penis. A large amount of drainage into all of these systems is also a contraindication to surgery.

More recently, CT imaging has been suggested in lieu of DICC to evaluate the penile venous drainage. After injection of a vasodilating agent, Virag and Paul reported on 38 patients who had dilute contrast injected into the corporal bodies and three-dimensional CT reconstructions obtained to evaluate prominent venous drainage (22). They suggest that this may be an option in the future that is less invasive and easier to perform. At this time, however, protocols for its use in the diagnosis of venous leak are not well defined, and we continue to perform DICC prior to any venous procedure for VED.

ALTERNATIVE TREATMENT OPTIONS

All men thought to have either focal arteriogenic or VED should undergo a trial of medical management. Many patients, regardless of the etiology of their ED, will respond to medical management with oral phosphodiesterase type 5 (PDE5) inhibitors. It has been suggested that a PDE5 trial may be performed in most men even prior to an extensive workup because their efficacy lessens the likelihood of surgically significant arterial or venous pathology (23). Other conservative options include a vacuum erection device with or without a penile band. The band is an especially useful conservative option in patients with VED because it acts to counteract the leak. Patients not responding to these agents should be offered a trial of intracavernosal injections with either prostaglandin E_1, papaverine, and/or phentolamine. Intraurethral prostaglandin (MUSE) is also an option for patients not willing to attempt penile injections. Patients not responsive to more conservative measures should be counseled on available surgical options, including arterial or venous surgery (when indicated) or penile prosthesis placement.

ARTERIOGENIC ERECTILE DYSFUNCTION

Patient Selection

Patient selection is paramount when considering penile arterial bypass for the treatment of ED. All patients should have a normal neurologic and endocrine evaluation. Younger patients without associated vascular comorbidities will achieve the most optimal outcome, although limited comorbid conditions are not an absolute contraindication. Current and past tobacco use will lead to worse outcomes, and patients should be counseled accordingly (24). All patients should have the diagnosis confirmed with penile duplex ultrasound without suggestion of veno-occlusive dysfunction. Focal lesions should be confirmed with selective pudendal angiography and appropriate recipient and donor vessels should be identified. At our institution, we primarily offer revascularization to patients with bilateral complete occlusion of the internal pudendal or common penile arteries without reconstitution through collaterals; however, arterial bypass has been performed in patients with unilateral lesions only.

Surgical Technique

All our penile revascularization surgeries are performed in a similar fashion, by anastomosing the deep inferior epigastric artery (IEA) to the dorsal penile artery in an end-to-side fashion (Fig. 70.2). The side chosen for anastomosis is based on the vessel with the largest diameter both on angiogram and intraoperative findings. Occasionally, we do anastomose the right IEA to the left dorsal penile artery, or vice versa, but this is rare. Each surgery is performed using a two-team approach with urology and plastic and reconstructive surgery working simultaneously. All anastomoses are performed using standard microvascular technique.

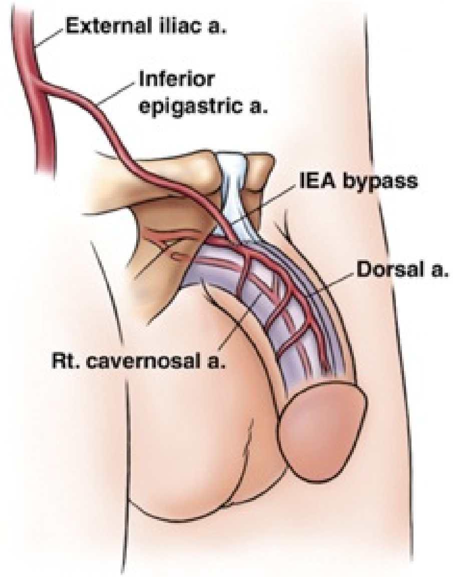

FIGURE 70.2 Arterial anatomy for penile revascularization. *IEA*, inferior epigastric artery.

Patients are admitted to the hospital the day of surgery. They are taken to the operating room and placed on general endotracheal anesthesia. All are given preoperative prophylactic antibiotics usually with a second-generation cephalosporin within 60 minutes of the skin incision. Patients are positioned supine with a slight frog leg then prepped with Betadine and draped using sterile technique from the xiphoid down to the knees. The procedure begins with isolation of the dorsal arteries bilaterally. A small infrapubic incision is made just above the penis. Dissection is carried down until the superficial dorsal vein is identified and either mobilized or ligated. Buck fascia is opened in the midline on top of the deep dorsal vein and mobilized laterally. The dorsal arteries are identified bilaterally and secured with a vessel loop.

After controlling the dorsal arteries, confirming the feasibility of the vascular anastomosis and selecting the best recipient vessel, we begin dissection of the deep IEA. A paramedian incision is extended from the pubic symphysis past the umbilicus for several centimeters on the selected side. The lateral aspect of the anterior rectus sheath is identified and incised through its entire length. The lateral border of the rectus abdominis is elevated and retracted medially, revealing the deep IEA beneath it. The artery is dissected free superiorly as far as necessary to provide adequate pedicle length for the anastomosis, usually to the level of the umbilicus (Fig. 70.3). If the artery enters the rectus muscle early in its course, it is carefully freed from the muscular attachments with bipolar forceps. We always harvest the artery with its attached vena comitantes.

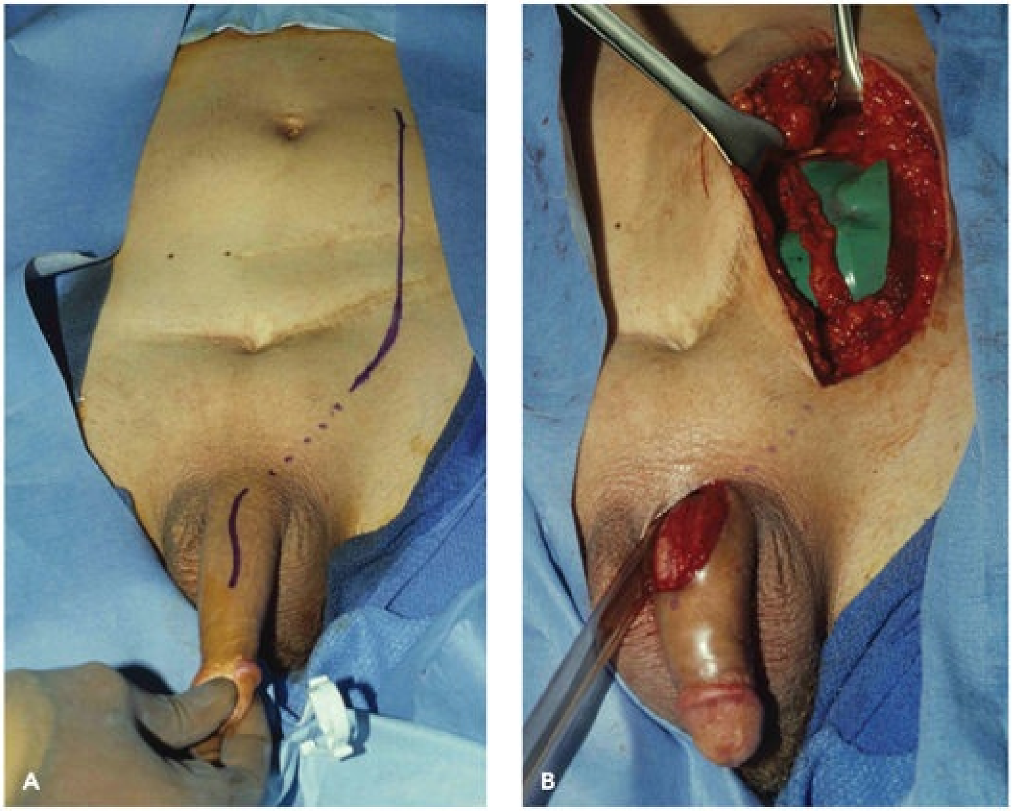

FIGURE 70.3 **A and B:** Dissection of the IEA and dorsal penile artery.

We then divide the deep inferior epigastric vascular pedicle at the distal extent of our dissection and pass it, with the help of a 36Fr chest tube, in a subfascial manner to the dorsum of the penis. Small hemoclips secure the vessel during passage. Gentle suction on the tube can aid in the transposition of the vessel. An operating microscope is then brought into the field. Vessel clamps are placed on the selected dorsal artery and an arteriotomy is made. The arteriotomy must be made with care. In most cases, the internal diameter of the dorsal penile artery is quite small with the majority of the vessel diameter related to the thickness of the media of the vessel wall. Rather than excision of vessel wall for arteriotomy, one should perform a careful incision of the vessel wall (Fig. 70.4). The donor IEA is anastomosed to the dorsal artery in an end-to-side fashion using interrupted 10-0 Prolene suture on a 75-micron needle (Fig. 70.5). The patency of the anastomosis is confirmed with Doppler ultrasound intraoperatively, and revisions are made if necessary. A closed suction drain is placed beneath the rectus muscle and the incisions are closed in layers with a subcuticular closure of the skin.

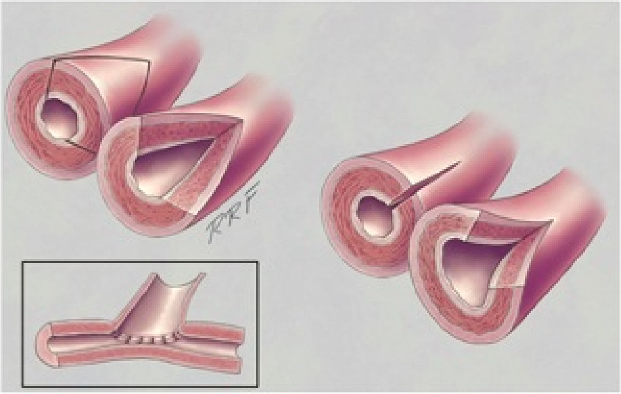

FIGURE 70.4 End-to-side microvascular arterial anastomosis. Inset: sagital view after completion of the microvascular anastomosis.

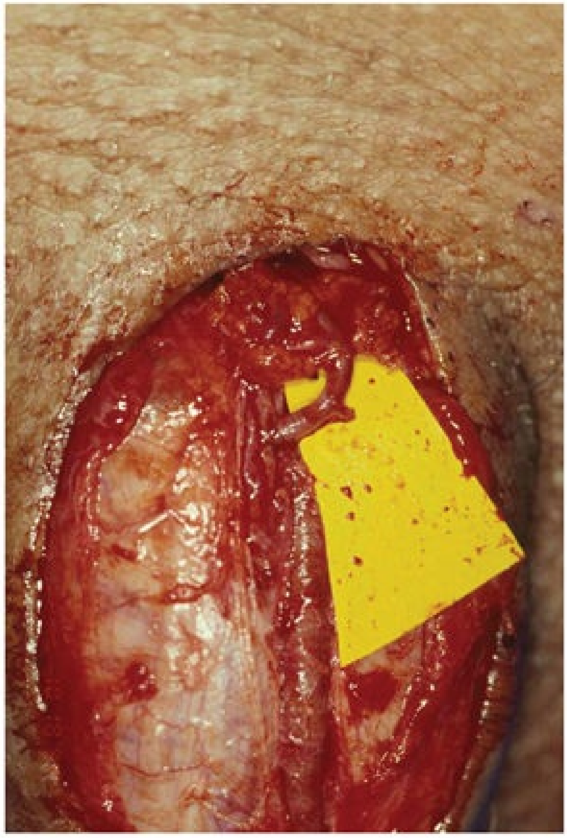

FIGURE 70.5 Completed arterial anastomosis.

Postoperatively, patients are maintained on bedrest for 2 to 3 days and most often discharged home on postoperative day 4 or 5. All patients receive subcutaneous heparin while inpatient for deep venous thrombosis prophylaxis, and 81 mg of aspirin is prescribed postoperatively in an effort to decrease the risk for graft thrombosis. Patients are seen back in the office weekly for a wound examination. A repeat penile duplex is obtained in all patients no sooner than 6 weeks postoperatively. Patients not achieving spontaneous erections at initial follow up are offered pharmacologic assistance with either oral PDE5 inhibitors or intracavernosal injections to augment their erections.

Outcomes and Complications

Surgeons have been performing penile revascularization for arteriogenic ED for nearly 40 years (25). Although initial results were poor, subsequent modifications to the original procedure have shown improved outcomes as demonstrated by more contemporary series (24,26–29). A variety of surgical techniques have been described in the literature with varying success. It is often difficult to objectively compare them because both the measures of success and included patient populations are often quite disparate.

The majority of case series following penile arterial bypass grafting include patients with a variety of ED etiologies who were subsequently found to have arterial insufficiency. Kayigil and colleagues reported on 110 patients undergoing penile revascularization (29). Procedures were performed using a Furlow-Fisher modification of the Virag procedure with an end-to-side anastomosis of the IEA to the deep dorsal vein. The vein was then ligated proximal to the arteriovenous anastomosis. They found an overall success rate based on International Index of Erectile Function (IIEF) questionnaires of 72.7%, although this decreased significantly over time in those with extended follow-up. Results were complicated by graft thrombosis in 11 patients (10%), penile edema in 9%, and glans hypervascularity in 6%, requiring subcoronal venous ligation. In this series, two patients had ED as a result of a pelvic fracture, but the results of these patients were not independently reported.

Vardi and associates presented their results performing penile revascularization in 52 patients with a variety of operative techniques, including IEA to either the dorsal artery, dorsal vein, or both the artery and the vein (24). All were performed in an end-to-side fashion. Of their patients, 10 developed arteriogenic ED following a pelvic fracture. They defined success as erections satisfactory for intercourse without use of pharmacologic assistance. Overall, their success at a mean follow-up of 70.8 months was 48% using this strict definition. Specifically, looking at patients with ED from a pelvic fracture, 50% had satisfactory erectile function with at least 2 years of follow-up. They found that younger patients (<28 years of age) had significantly improved outcomes compared with older patients. Nonsmokers also had improved outcomes compared with active tobacco users.

We recently reported our own experience performing an IEA to dorsal penile artery end-to-side anastomosis in 17 patients with arteriogenic ED following PFUIs (30). The average age was 32.7 years, and mean follow-up was 3.1 years (0.3 to 9.5 years). Success, defined as ability to obtain an erection sufficient for intercourse, was enjoyed by 14 of the 17 patients (82%). Of the patients not achieving a successful outcome, two were active smokers and one was simply lost to follow-up. Postoperative duplex parameters normalized and no patients experienced thrombosis of the anastomosis (Table 70.1). Four patients (24%) experienced early (<3 months) postop complications, including an abdominal wall hematoma requiring evacuation in one (Clavian grade IIIb), penile edema requiring an extended hospital stay in two (Clavian grade I), and a superficial surgical site infection requiring outpatient antibiotics in one (Clavian grade II) (31). There were no late (>3 months) complications. Only one patient underwent subsequent ED surgery with placement of inflatable penile prosthesis.

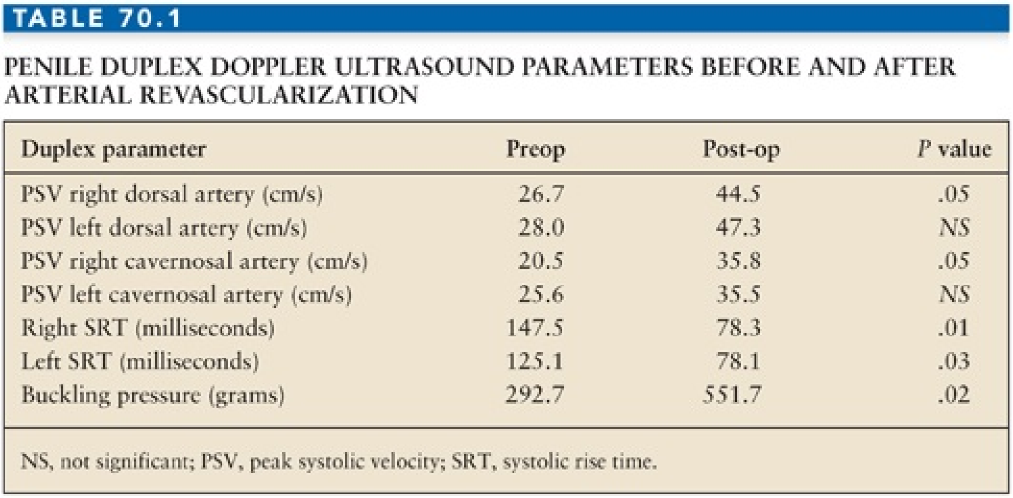

TABLE 70.1

PENILE DUPLEX DOPPLER ULTRASOUND PARAMETERS BEFORE AND AFTER ARTERIAL REVASCULARIZATION

Duplex parameter	Preop	Post-op	*P* value
PSV right dorsal artery (cm/s)	26.7	44.5	.05
PSV left dorsal artery (cm/s)	28.0	47.3	NS
PSV right cavernosal artery (cm/s)	20.5	35.8	.05
PSV left cavernosal artery (cm/s)	25.6	35.5	NS
Right SRT (milliseconds)	147.5	78.3	.01
Left SRT (milliseconds)	125.1	78.1	.03
Buckling pressure (grams)	292.7	551.7	.02

NS, not significant; PSV, peak systolic velocity; SRT, systolic rise time.

Early in our experience, we chose to perform an end-to-side anastomosis of the IEA to the dorsal penile artery and have continued this approach in all our patients. We initially chose this technique based on prior reports showing problems with glans hyperemia as well as graft thrombosis likely secondary to the venous valves inherent in any arteriovenous anastomosis (32–34). Our surgical approach has not changed significantly over time because we have found it efficacious in the majority of our patients. Although an end-to-end IEA to dorsal penile artery anastomosis has been described with acceptable outcomes (28), we feel that the end-to-side approach has a theoretical advantage of allowing a bidirectional flow of blood following microvascular anastomosis and the potential to allow more collateralization from the dorsal to the cavernosal artery (Figs. 70.6 and 70.7). However, given the lack of direct comparison between these two techniques and the relatively high success rate of each of them with this difficult patient population, it is likely more important that the surgeons use the approach they feel most comfortable performing.

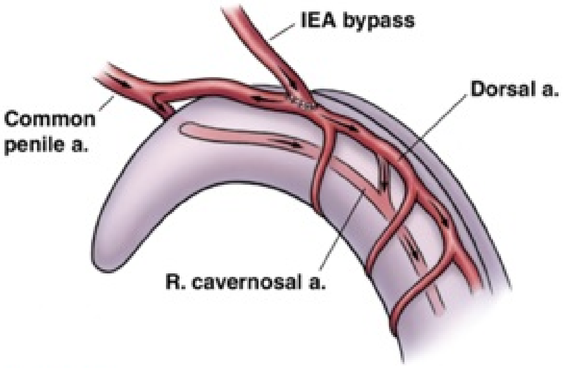

FIGURE 70.6 Blood flow following arterial revascularization. *IEA*, inferior epigastric artery.

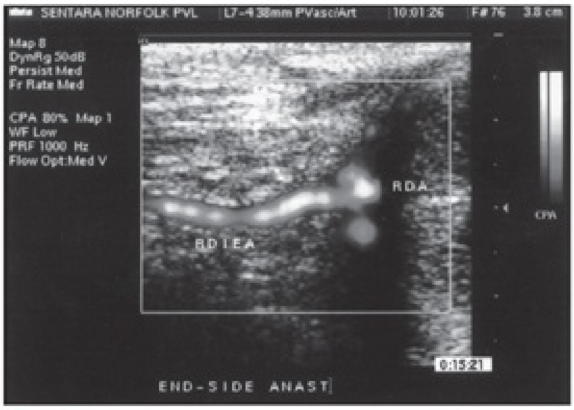

FIGURE 70.7 Duplex Doppler ultrasound demonstrating bidirectional blood flow following revascularization.

As we enter an era of more cost conscious health care, it is important to consider whether a treatment is cost-effective. The charges for the initial procedure and hospital stay in current dollars for one of our recent patients was $32,245. A portion of this cost is obviously related to the extended inpatient stay, which we have not found has significantly decreased over the course of our experience performing this procedure. Much of this hospital stay is related to the extended period bedrest (2 to 3 days) that we feel is essential for the success of these procedures. Placement of an inflatable penile prosthesis is a potential alternative procedure in some of these patients to treat their ED. Similar cost analysis for initial placement of the shows charges of $36,825, slightly higher than the cost of revascularization. The implant itself makes up a portion of the increased costs. In addition to increased costs of initial placement, given the traditionally younger cohort that comprises this population, patients can expect one or more device revisions over their lifetime, adding additional costs and morbidity.

Similar to other aspects of vascular surgery, endovascular treatment of internal pudendal stenosis in men with arteriogenic ED failing medical management has been reported (35). Rogers and associates reported on the use of a Zotarolimus-eluting stent in 30 patients for significant unilateral or bilateral internal pudendal artery stenosis. Preoperative workup was appropriate, including IIEF questionnaires, penile duplex ultrasounds, and pelvic angiograms. They did not note any adverse events secondary to stent placement. On follow-up duplex ultrasound at 6 months, the peak systolic velocity in the cavernosal arteries increased an average 22.5 cm per second. Intention to treat analysis demonstrated that 59.3% of patients experienced at least a 4-point increase in their IIEF score at 6 months following the procedure (mean 12.5 point increase overall). On follow-up angiogram at 6 months postprocedure, binary restenosis of the stent was noted in 34% of patients despite dual antiplatelet therapy with aspirin and clopidogrel through that time point. Currently, endovascular stenting remains investigational and long-term follow-up remains unknown. However, the minimally invasive nature and relatively less morbidity associated with the procedure may make this an attractive option for patients in the future.

CORPORAL VENO-OCCLUSIVE ERECTILE DYSFUNCTION

Patient Selection

As with patients being considered for arterial bypass procedures, patient selection for surgical intervention in the setting of VED is equally critical. Long-term outcomes following venous surgeries have been poor, and patients should be counseled accordingly. All patients being considered for venous surgery for VED must have venous leak suggested by history and diagnosed with penile duplex Doppler ultrasound. The location of the leak and confirmation of the diagnosis should be obtained with DICC prior to intervention. As mentioned previously, those patients with diffuse corporal dysfunction rather than an area of focal leak do not fare as well following venous surgery and should be encouraged to pursue alternative treatment options. Ideally, patients selected for surgery are younger (<50 to 60 years of age) with limited comorbidities, specifically limited or no concomitant vascular disease. It is imperative to document adequate arterial inflow on preoperative duplex ultrasound.

Patients should be offered a trial of more conservative treatment options prior to venous surgery. Those with mild venous leak may respond to oral PDE5 inhibitors. Intracavernosal injections can allow for a functional erection in men with a moderate leak, especially when combined with a penile band. Vacuum erection devices may be used as monotherapy or combined with either PDE5 inhibitors or injection therapy. Finally, patients should be counseled on penile prosthesis placement as an alternative surgical option.

Surgical Technique

The procedure is performed under general endotracheal, or less commonly spinal, anesthesia. A second-generation cephalosporin or fluoroquinolone antibiotic are administered within 60 minutes of skin incision. The patient is positioned on the table in the supine position with a slight abduction to the legs for access to the perineum and then prepped and draped in sterile fashion. Alternatively, dorsal lithotomy position can be used if further access to the perineum is required. A thorough understanding of penile venous anatomy is imperative for a successful procedure (Fig. 70.8).

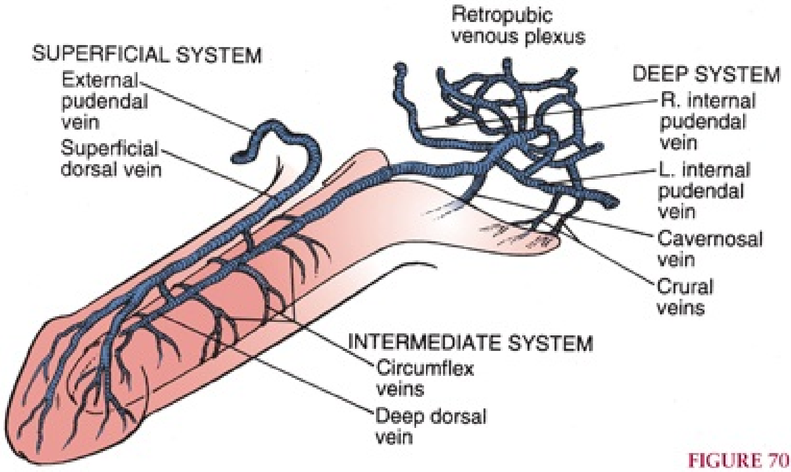

FIGURE 70.8 Penile venous anatomy.

A variety of incisions can be used for dorsal vein ligation, including dorsal penopubic, parapenile, or dorsal longitudinal penile (Fig. 70.9). A circumcising incision also provides reasonable exposure, although this can be associated with postoperative numbness. Whichever approach chosen, superficial tissue is dissected free of the corporal bodies easily with sharp and blunt dissection. The superficial dorsal vein is identified and ligated. Buck fascia is cleared and incised in the midline directly over the deep dorsal vein. The vein is dissected free of the tunica albuginea. Communicating circumflex and emissary veins branching off the deep dorsal vein can be controlled with bipolar cautery or 4-0 polyglactin sutures. Proximally, the vein is dissected until about 1 cm from the glans and ligated with 3-0 polyglactin ties. It is important to remain midline during this dissection to avoid injury to the dorsal artery and nerves. Distally, the vein is dissected up to the pubic bone and similarly ligated (Fig. 70.10).

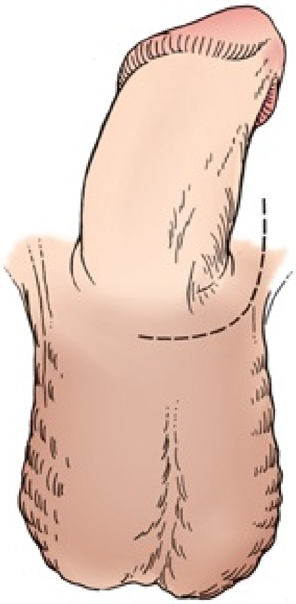

FIGURE 70.9 Parapenile incision (dashed line) for venous ligation.

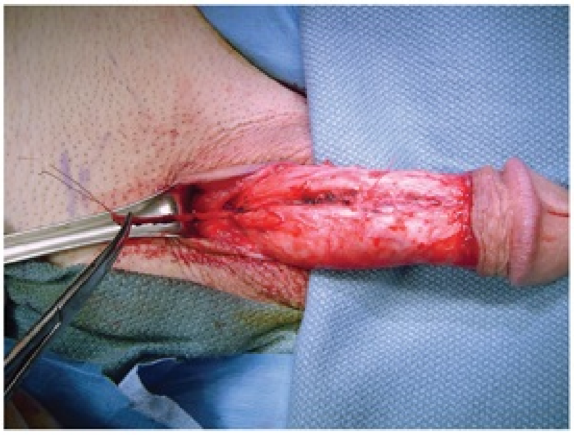

FIGURE 70.10 Dorsal vein ligation using a circumcising incision.

We do not routinely incise the suspensory ligament, but if this dissection is planned, the fundiform and suspensory ligament are both transected close to the underside of the pubic symphysis (Fig. 70.11). With the penis detached from the pubis, it is possible to dissect the dorsal vein more proximally into the hilum of the corpora. In this location, you may also divide the cavernosal veins if they are a significant source of venous leak. The cavernosal arteries and nerves in this area must be prospectively identified and preserved such that they are not injured if cavernosal vein ligation is performed.

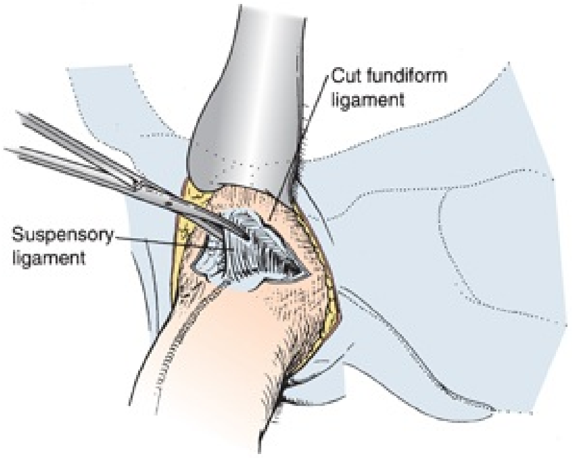

FIGURE 70.11 Ligation of the fundiform and suspensory ligaments.

The wound is closed in layers, and skin adhesive is used to dress the incision. A drain is not routinely left, although a TLS drain may be helpful for patients with significant bleeding during that case and who will be kept overnight. A compressive penile and scrotal dressing is not usually required. Most patients can be discharged on the day of surgery.

Crural banding can be performed in conjunction with dorsal vein ligation or as a standalone procedure. If performed at the same time as a dorsal vein ligation, a parapenile incision is usually simply extended further onto the scrotum for exposure. Otherwise, either a perineal or penoscrotal approach can be used, although a perineal incision is limited in its ability to ligate the crura proximally and may not be as useful in those patients with proximal or extensive crural venous leak. For the penoscrotal approach, a transverse scrotal incision is made, and the crura are identified and separated from the corpus spongiosum. A right-angle clamp can then be passed from medial to lateral around the crus on each side and cotton tape ligatures are used to ligate the crura. One or two ligatures can be used depending on the severity of the leak (Fig. 70.12).

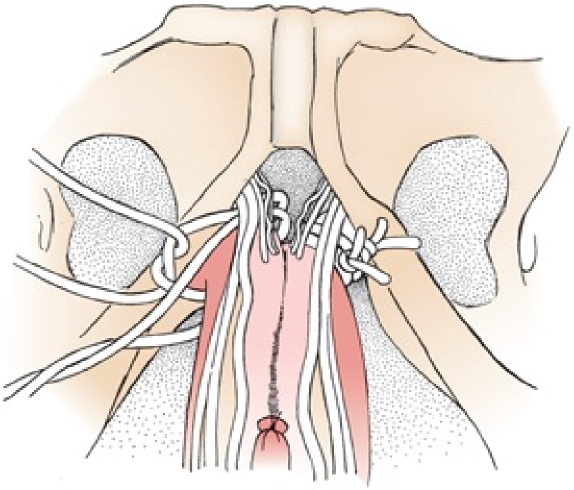

FIGURE 70.12 Crural banding following dorsal vein ligation.

Outcomes and Complications

Ideally, surgery for veno-occlusive dysfunction should be aimed at the prominent site of leakage found on cavernosography. For those patients with primary leak through the dorsal vein, treatment has been directed at superficial and deep dorsal vein ligation. Following introduction of dorsal vein ligation surgery, early results had been promising (36,37,38). Long-term outcomes, however, have consistently been less impressive, and this has not changed dramatically in more contemporary case series. Berardinucci and colleagues reported on 100 patients undergoing dorsal vein ligation for VED (39). They did not ligate cavernosal or crural veins. Defined as achieving an unaided erection sufficient for intercourse at least 50% of the time, they reported 3 months success rate of 62%. On telephone follow-up at average 45 months following surgery, however, success decreased to 31%. Complications were minimal, which they attributed to a more focused dissection and not incising the suspensory ligament. Given that the only other treatment option available to this group of patients is a penile prosthesis, they concluded that the procedure continues to be a reasonable option in select patients.

Similarly, Popken and associates reported their results on 122 patients who underwent venous ligation surgery for VED (40). In addition to the deep dorsal vein, they also ligated the crural vein in 38% and other ectopic veins in 26%. Unaided erections sufficient for intercourse were only found in 28% at 6 months and 14% at 70 months of follow-up. An additional 19% were able to achieve an erection with intracorporeal injections such that 33% of patients were considered to have benefited from the surgery. Complications in this series were 7% and mild in nature, with edema of the prepuce being the most common.

More recently, crural ligation procedures have been suggested to treat VED, especially for those patients with isolated corporal venous leak. These have been performed as standalone procedures or combined with vein ligations. Lue initially described the procedure, and in 2005, he reported on 11 patients undergoing crural banding in combination with dorsal vein ligation performed through a penoscrotal incision (41,42). Patients with diffuse or multifocal leak on cavernosography were excluded. The suspensory ligament was completely incised, but the tunica albuginea was reapproximated to the pubic bone prior to closure. Of the 11 patients, 9 noted marked improvement in their erectile function at a mean follow-up of 34 months. Penile shortening, which is a known complication following incision of the suspensory ligament, was not noted in any patient. This was thought to be secondary to reapproximation of the penis to the pubic bone with tunical fixation sutures.

In 2008, Cayan described his results using Lue's technique in 26 men found to have VED with a leak confirmed on cavernosography (43). Mean postoperative follow-up was 43.9 months. ED resolved completely in 42.3% of men. Increases in IIEF scores were seen from 6.7 preoperatively to 16.3 following surgery. No patient complained of penile shortening or numbness, but wound infections were noted in 7.7%. Similarly, Flores and colleagues performed corporal banding in 14 patients found to have isolated corporal leak and followed them with IIEF questionnaires (44). At an average of 16 months following surgery, the mean IIEF increased from 18 to 24 ($P = .01$). Sixty-six percent of the patients were able to have unassisted sexual intercourse.

There are a number of reasons why venous surgery might fail over time. Some of these patients likely have concomitant arterial disease, making the veno-occlusive function more tenuous. It has been theorized by some that collateralization of flow over time overcomes ligation procedures. Others refute this, suggesting that less complete dissections might lead to poorer outcomes (45). It is likely that a high rate of failures is seen because none of these procedures address diffuse corporal dysfunction that may be present in a portion of these patients. Inability of the sinusoidal spaces to expand secondary to atrophy or fibrosis and lack of rigidity within the tunica albuginea will prevent occlusion of the emissary veins no matter how meticulous or involved the surgical technique. Although crural banding appears to improve operative outcomes, durable success has only been reported in small case series. It is important to note, however, that patients not achieving spontaneous erections may still derive benefit through PDE5 inhibitor therapy. Nonresponders to PDE5 inhibition preoperatively who undergo venous surgery are more likely than patients who did not undergo surgery to respond to this class of medication and should rechallenged if spontaneous erections are not sufficient for intercourse (46). This fact and the portion of patients who enjoy a sustained response would suggest that these procedures still have a place in the management of VED.

CONCLUSION

ED affects a diversion population and is a common reason for presentation to urology practices. In the majority of patient, conservative treatments with PDE5 inhibitors, intracavernosal injections, or vacuum erection devices are sufficient treatments. Patients found to have either significant focal arterial insufficiency or veno-occlusive incompetence may benefit from surgical intervention.

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CHAPTER 71 PENILE TRAUMA

JUDITH C. HAGEDORN AND DANIEL I. ROSENSTEIN

Trauma to the penis is an uncommon event. Because of the relatively protected position of the penis between the thighs and pubic bone, it is usually able to avoid direct injury from external forces. Nonetheless, penile trauma may arise from both blunt and penetrating injuries. Such injuries present unique and difficult management problems to the urologic surgeon, in particular regarding long-term cosmesis, voiding function, and future potency. Major blunt penile injuries include penile rupture and skin loss from strangulation or degloving injuries. Penetrating penile trauma is usually secondary to stab or gunshot wounds and thus seldom occurs in the absence of associated genital, urethral, or major organ injury, except in the event of bites and self-inflicted wounds. Due to the wide disparity in the causes, diagnosis, and treatment, this chapter is divided into three parts: penile rupture, penile skin loss, and penetrating penile trauma.

PENILE RUPTURE (PENILE FRACTURE)

The most common blunt injury involving the penis is rupture of the corpora cavernosa, or penile fracture. This almost invariably occurs when the erect penis is forced to bend in an irregular fashion, such as when it accidentally impinges on the pubis or perineum during sexual intercourse (1). The remainder of cases is caused by falls out of bed with an erect penis, masturbation, or manipulation of the erect penis. Recently, penile crush injury due to the accidental fall of a toilet seat has been described as an uncommon cause of genitourinary trauma (2). The patient often reports a cracking or popping noise at the time of injury, leading to immediate detumescence and rapid onset of discoloration and swelling over the site of injury. There is frequently a delay in presentation to the hospital—presumably secondary to patient embarrassment.

Diagnosis

The diagnosis of penile rupture is easily made by physical examination along with the appropriate history. Swelling and discoloration may or may not be limited to the penis, depending on the integrity of Buck fascia. If Buck fascia is intact, the hematoma will be contained and will not usually spread below the base of the penis, resulting in the typical “eggplant” deformity (Fig. 71.1).

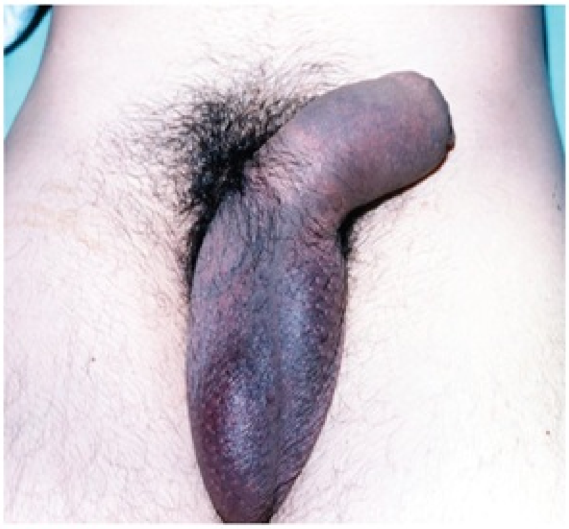

FIGURE 71.1 Fractured penis displaying the pathognomonic “eggplant” deformity with swelling and discoloration extending to the base of the shaft and, in this case, into the scrotum.

However, if the laceration in the tunica albuginea also lacerates through Buck fascia, extravasation will be contained by Colles fascia and ecchymosis will extend in a “butterfly” distribution over the perineum, scrotum, and lower abdomen. Examination may reveal angulation of the penis away from the side of rupture because of the mass effect of the hematoma. In addition, focal tenderness and a palpable defect in the tunica albuginea may help localize the fracture site. There is often a clot lying over or near the fracture site that corresponds to the site of cavernosal rupture. Imaging studies for the diagnosis of penile rupture are unnecessary after a thorough history and physical exam, but recent studies have described penile ultrasound as a low-cost supplement examination that can be easily performed and may be of value in identification of the rupture location (3). In addition, magnetic resonance imaging is a very accurate modality but of limited availability and practicality in this setting (4).

Penile rupture can occur anywhere along the shaft, including the base of the penis, where the corpora are fixed by the penile suspensory ligament. The fracture is typically transverse in orientation and located at the base of the penis, just proximal to the penoscrotal junction. However, longitudinal, distal fractures have been described in 30% of cases (4). In general, only one corporal body is injured, although both corpora and the corpus spongiosum can be affected depending on the severity of the injury. Most patients are able to urinate normally, but the urologist must maintain a high index of suspicion for urethral injury. Failure to void spontaneously may signify compression of the urethra by hematoma but should lead to evaluation of urethral injury by retrograde urethrography (RUG). Urethral injury occurs in up to one-third of cases and usually consists of partial disruption, although complete transection can result (4,5). RUG is mandatory in all patients with blood at the urethral meatus, hematuria of any extent, or inability to void (1). However, because RUG is easy to perform and provides reliable results, we perform it routinely in all cases of suspected penile rupture. Adjunctive imaging studies in penile fracture (including ultrasound, magnetic resonance imaging, and cavernosography) are usually unnecessary as the clinical picture is frequently adequate to initiate therapy (6).

Indications for Surgery

Although penile fractures can be managed nonoperatively, the literature shows a clear advantage to early operative repair (1,5). This approach results in faster recovery, shorter hospital stay, less morbidity, and less long-term penile curvature. The goals of acute exploration are evacuation of the hematoma and primary repair of the laceration and should be undertaken even in patients with delayed presentation (7). Of note, dorsal vein injury may mimic the presentation of penile rupture and may lead to a negative penile exploration (8).

Alternative Therapy

Conservative treatment consists of cool compression dressings, anti-inflammatory agents, and sedatives to reduce the frequency of erections. This results in eventual resorption of the hematoma and scar formation at the site of the tunical rupture. Conservative management is associated with significant complications in up to 50% of patients, including hematoma formation, corporal fibrosis and curvature, pseudoaneurysm of the corpora, and erectile dysfunction (8,9). Several studies have shown that surgical exploration and repair of the penile fracture leads to superior outcomes and therefore should be undertaken when the injury is suspected (10–12).

Surgical Technique

The patient is placed in a supine position and a Foley catheter is placed to facilitate identification of the urethra and urinary drainage. Exposure is usually obtained through a subcoronal circumferential incision, and the penile skin is degloved down to the base. The distal circumferential incision is favored because it allows both exposure of the ruptured corpus and adequate assessment of the contralateral corpus and corpus spongiosum. Alternatively, an incision may be made on the shaft directly over the fracture site. This approach is only useful if the fracture is palpable or seen on preoperative imaging, as the corporal bodies may not be easily explored through this incision. Further, the corpus spongiosum cannot be directly inspected via this approach.

Following the circumcising incision, the corpus spongiosum is carefully inspected to evaluate for potential urethral injury. Inspection of the fracture site usually reveals a transverse laceration, between 0.5 and 2.0 cm long, in the tunica albuginea of the proximal penile shaft (13). After evacuation of the hematoma and irrigation, minimal debridement of nonviable wound edges may be necessary before closure with interrupted 4-0 monofilament synthetic absorbable sutures (Fig. 71.2A and B).

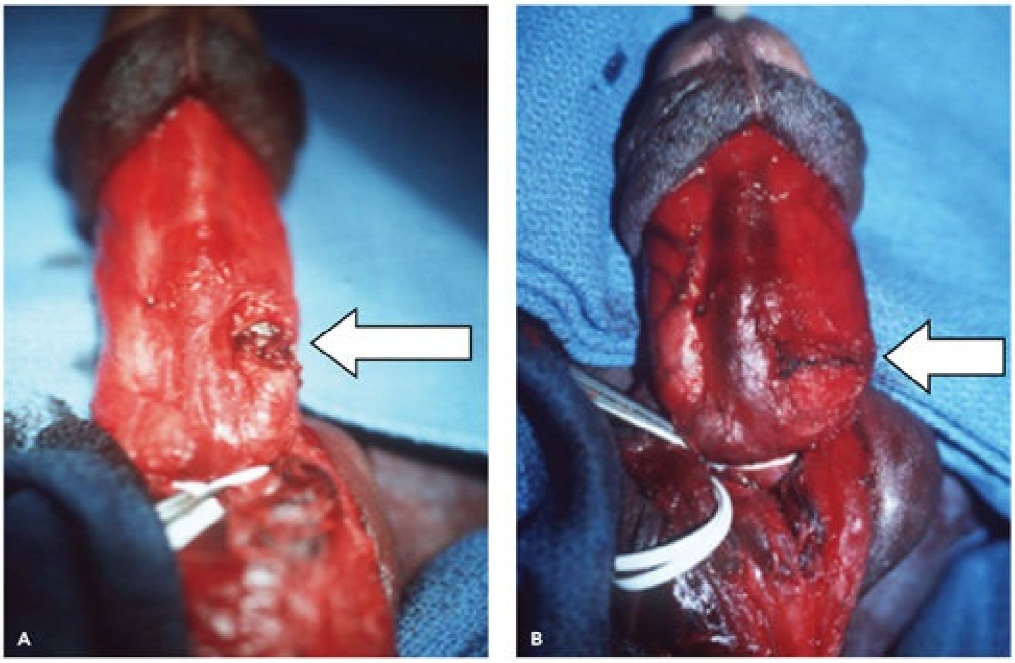

FIGURE 71.2 Identification and repair of penile fracture. A distal circumferential subcoronal incision is made and skin and soft tissue are mobilized off the underlying corporal bodies down to the base of the penis. Note that a white elastic tourniquet has been temporarily applied around the base of the penis. **A:** This maneuver exposes the transverse laceration in the tunica albuginea. *Arrow* points to site of corporal laceration. **B:** The laceration is repaired using interrupted 4-0 monofilament suture with the knots buried. *Arrow* points at laceration repair. Exposed corporal erectile tissue should not be probed or explored as this may cause troublesome bleeding.

The surgeon should not probe the exposed cavernous tissue unnecessarily as this may elicit troublesome bleeding. A tourniquet may be used intraoperatively to control hemorrhage. Lacerations may run directly under the dorsal neurovascular bundle located on the dorsal surface of the corpora at approximately the 10 and 2 o’clock positions (Fig. 71.3).

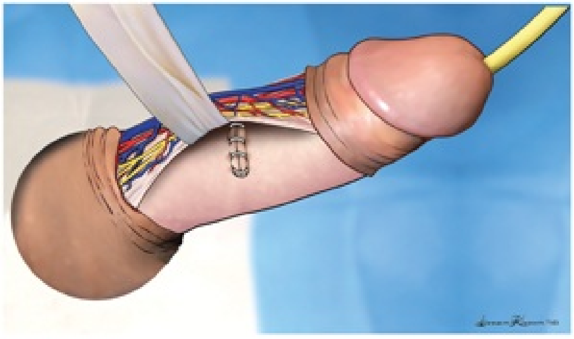

FIGURE 71.3 Penile fracture extending beneath dorsal neurovascular bundles. Elevation of the ipsilateral dorsal neurovascular bundle facilitates repair of lacerations and protects these structures from inadvertent injury.

This necessitates careful dissection of these structures off the corpora to allow a safe, watertight closure. Division of the deep dorsal vein facilitates unilateral dissection of the neurovascular bundle off the underlying corpus cavernosum. The penile skin is then replaced and the subcoronal incision is closed with interrupted 4-0 chromic sutures. If the patient is uncircumcised, the prepuce must be closely monitored for development of subcoronal edema. Postoperatively, a loose compression dressing (Coban) is gently placed, and the urethral catheter may be removed on postoperative day 1 (assuming no urethral repair was required). Systemic antibiotics, anti-inflammatory agents, and fibrinolytics are unnecessary. Most patients can be discharged home within 1 to 2 days of surgery. Sexual activity can be resumed at about 4 to 6 weeks. Painful erections may be present in the early postoperative period. Suppression of erections with benzodiazepines or amyl nitrate may provide symptomatic relief.

When urethral transection occurs in the context of penile rupture, we advocate primary repair with interrupted 5-0 or 6-0 synthetic, absorbable, monofilament sutures over a 16Fr silicone catheter. In cases of complete urethral transection, additional urinary diversion through a percutaneous suprapubic cystostomy tube may be prudent (1). A voiding cystourethrogram (VCUG) should be carried out at approximately 14 days postrepair to document adequate healing before catheter removal.

Outcomes

Complications

Penile fracture has potential complications, particularly when managed nonoperatively or with delayed repair. However, patients who undergo immediate surgical exploration may also develop some form of sexual dysfunction, such as painful erection, disabling curvature, or erectile dysfunction secondary to corporal veno-occlusive disease (8,14). Patients with a missed urethral injury associated with penile fracture are also at risk of periurethral abscess, stricture, and fistula formation.

Results

Patients who have operative repair within 48 hours of the injury have excellent functional results. In two relatively large studies, none of the patients with early operative repair experienced impotence, penile curvature on erection, or painful intercourse (1,13). Patients with delayed presentation of up to 7 days postinjury have acceptable postsurgical outcomes, even though the rate of chronic penile curvature is higher with delayed exploration (6,7).

PENILE SKIN LOSS

Diagnosis

Penile skin loss can occur from necrotizing infections, burns, constrictive bands, or degloving injuries from blunt or penetrating trauma, frequently resulting from farm machinery mishaps and motorcycle or bicycle accidents. Dog and human bites may also result in considerable penile skin loss and may lead to polymicrobial infection (6). When the skin loss is secondary to infection (e.g., Fournier’s gangrene), repeated debridement with antibiotics and moist dressing changes must be instituted to prepare the underlying tissue for delayed reconstruction (Fig. 71.4).

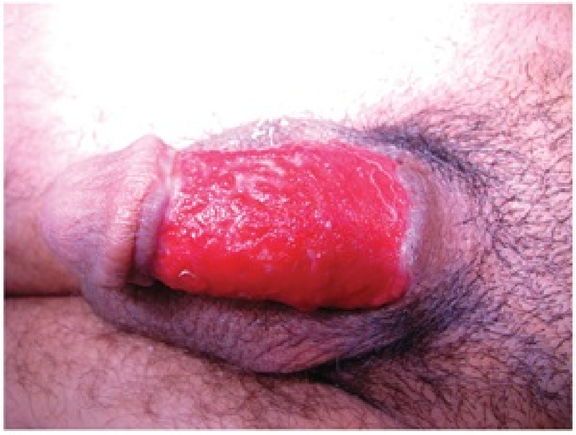

FIGURE 71.4 Debrided penile shaft in a patient who presented with Fournier gangrene of the penis. The penile shaft has healthy granulation tissue and no signs of infection after debridement and wet-to-dry dressing changes.

Avulsions are most often caused by power tool injuries or motor vehicle accidents, although this injury may rarely be self-inflicted secondary to insertion of the penis into vacuum cleaners and other suction devices (15). Because of the laxity of penile skin, the avulsion usually extends just to the subcutaneous dartos layer, leaving the corporal bodies uninvolved. Immediate repair is frequently possible and advised in cases of traumatic skin loss (6). If immediate closure is to be attempted, the wound edges must be clean and viable and hemostasis must be excellent to avoid delayed skin necrosis and sloughing.

Indications for Surgery

Partial penile skin loss, especially in the distal shaft, is best managed by rotational mobilization of a local skin flap. Primary closure may be appropriate if the defect is short and there is abundant remaining shaft skin. Extensive skin loss, whether from the injury itself or surgical debridement, usually requires tissue transfer for repair. In impotent patients, the penis can be buried under a scrotal flap with the glans left exposed to allow micturition (13). The penis may be liberated at a later date using the scrotal skin as a graft to cover the previously denuded area. This approach obviously results in significant cosmetic deformity.

In sexually active patients, a thick (0.016- to 0.018-inch), nonmeshed split-thickness skin graft is used. Thick split-thickness grafts are preferred because they are non–hair-bearing, have minimal contraction, and offer excellent cosmesis and viability. A thinner (0.014- to 0.016-inch) skin graft may be harvested and meshed especially if sexual function is not a concern. Recent literature has shown satisfactory outcomes in sexually active patients even with thinner unexpanded meshed skin grafts (16). The avulsed skin that is still attached on a viable pedicle can be gently washed and reapplied with the knowledge that it may need to be debrided at a later time. Completely avulsed penile skin will usually not survive as a free graft if reapplied to the denuded penile shaft.

Alternative Therapy

There are no alternatives to surgery for genital skin loss.

Surgical Technique

The patient is placed supine and both the genitals and a carefully chosen donor site are prepared into the field. The anterolateral thigh provides thickness, texture, and color resembling penile skin and is therefore the preferred donor site. Alternatively, the medial or posterior thigh or buttock may be used as a skin donor site. A Foley catheter is placed to prevent postoperative urinary contamination. The shaved donor site is coated with sterile mineral oil, and a pneumatic dermatome (10-cm wide strip) is used to harvest the graft in an approximately 0.016- to 0.018-inch thickness. The graft is then tailored to fit the defect on the shaft. The donor site may be dressed with fine mesh gauze under slight pressure to ensure adequate hemostasis. Placement of a biosynthetic, semipermeable silicone membrane (e.g., Biobrane) directly against the donor site helps reduce contamination. After about 24 hours, the silicone membrane is adherent to the donor site and the redundant edges may be trimmed. This dressing usually falls off spontaneously after 2 weeks.

To prepare the penile shaft for grafting, it must be sharply debrided of all devitalized tissue and any chronic granulation tissue. It is imperative to prepare the recipient site so that the graft will have adequate blood supply. Debridement of the glans should be avoided, but all nonviable skin, including the distal prepuce, should be excised up to the coronal sulcus. Native penile skin distal to the graft will become edematous because of disruption of native lymphatic and venous drainage along the shaft. Hemostasis in the graft bed is essential to prevent hematoma formation under the graft.

Once prepared, the penis is stretched and the graft applied circumferentially around the shaft. Some experts have recommended spraying a thin layer of diluted fibrin sealant onto the recipient site for better graft adherence and take (17). The graft seam is placed at the ventral aspect to simulate the appearance of the median raphe. The graft is sutured in place using interrupted 5-0 chromic sutures (Fig. 71.5).

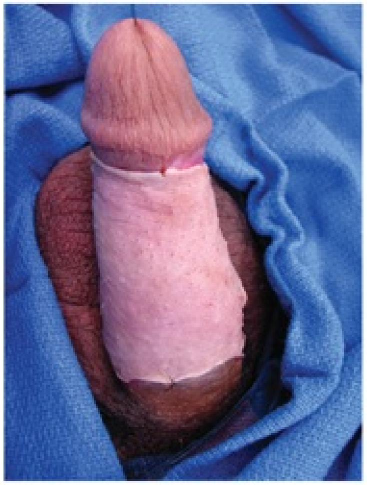

FIGURE 71.5 Penile nonmeshed split-thickness skin graft. A thick (0.016- to 0.018-inch) split-thickness skin graft is applied to the denuded penile shaft. The distal skin is discarded to just beneath the corona when a circumferential graft is indicated. The graft is placed with the seam in the midline ventrally and secured with 5-0 chromic sutures to itself and along the shaft.

Chordee formation has in general not been a problem because the graft will have minimal longitudinal contraction. The graft is secured to itself and along the shaft with interrupted 5-0 chromic sutures. Several 4-0 absorbable, synthetic, braided sutures are placed at the proximal and distal graft edges and left long to use as bolster tie-over sutures. A petroleum gauze nonadherent (e.g., Xeroform) dressing is placed directly on the graft. A bolster dressing is then fashioned using mineral oil–soaked cotton and fluffs (Fig. 71.6A). The whole dressing is secured in place using the bolster sutures, leaving the glans visible for inspection. To keep the penis in a vertical position, a padded plastic splint is placed around the bolster dressing. This housing may be fashioned out of a 500-mL sterile water container (Fig. 71.6B).

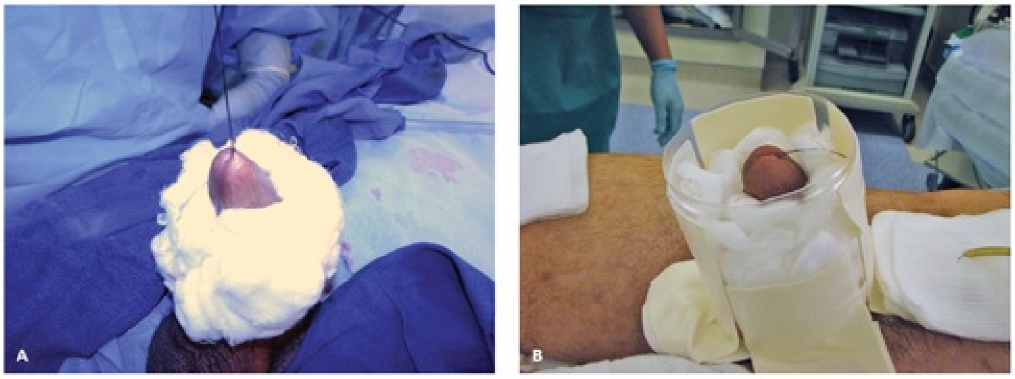

FIGURE 71.6 **A:** Mineral oil–soaked cotton is secured around the shaft. Several 4-0 absorbable sutures are placed at the proximal and distal graft edges and left long to use as bolster tie-over sutures. **B:** The penis is kept in a vertical position by a padded plastic splint fashioned out of a 500-mL sterile water container with the top and bottom cut off and secured to the patient with foam tape.

The use of topical negative pressure (vacuum-assisted closure) to split-thickness skin graft has mostly been described in the plastic surgery literature and has found a considerable advantage over traditional dressings in quality and quantity of graft take, including grafts to the penis and scrotum (Fig. 71.7) (18,19). The vacuum suction was set at 75 to 100 mm Hg and left in place for 4 to 5 days postoperatively with a graft take between 90% and 100% (19,20).

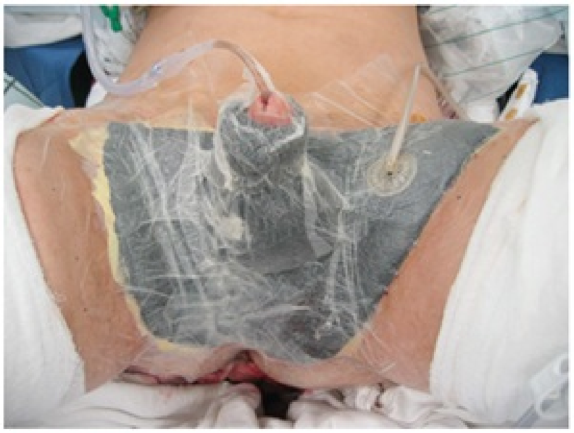

FIGURE 71.7 Vacuum-assisted closure (VAC) device on patient who has undergone skin graft resurfacing of penis, testes, and groins following debridement for Fournier's gangrene. The delicate grafts are further protected and adherent to the wound using the VAC device. (Reprinted by permission of Brandes SB, Morey AF. *Advanced Male Urethral and Genital Reconstructive Surgery*, 2nd ed. New York: Humana Press, 2013. Copyright 2014 Springer Science & Business Media.)

Postoperatively, the patient is kept at strict bedrest until the dressing is removed, usually after 5 days, when the Foley catheter is also removed. Immobilization of the penis in the extended position maintained by the bolster is critical for graft survival. Broad-spectrum antibiotics and administration of subcutaneous heparin for deep venous thrombosis prophylaxis are useful adjuncts. We do not routinely administer medications to reduce frequency of erections unless they are painful for the patient. Erections may provide natural tissue expansion, and the grafts usually slide easily along the loose areolar tissue superficial to the Buck fascia. Once the penile dressing is removed, twice-daily sitz baths can be started to enhance epithelialization and reduce bacterial contamination.

Outcomes

Complications

The common causes of early failure and loss of penile skin grafting are infection, graft separation, and underlying hematoma. It is imperative that the graft bed be free of infected granulation tissue and any necrotic tissue. Shearing forces disrupt the blood supply to the new graft and are prevented by the penile splint and bolster dressing, provided the patient is cooperative with strict bedrest for 5 days. It is critical that the penis be maintained in the extended position within the bolster dressing as this will prevent folding or telescoping of the fresh graft on the penile surface. Hematoma causes failure by creating poor contact between the graft and the recipient bed. It is prevented by ensuring meticulous hemostasis of the graft bed prior to laying the graft in place. Meshed grafts allow better dissipation of hematoma fluid and have recently shown to provide a satisfactory functional and cosmetic outcome, without the previously reported erectile dysfunction due to contraction (16).

Results

Long-term results of reconstruction have been excellent, with successful graft take exceeding 90%. Sensation remains absent in the grafted skin but is retained in the glans and in deeper structures. Potency is unaffected by this type of reconstruction. Most patients who were previously potent may have satisfactory intercourse after reconstruction.

PENETRATING PENILE TRAUMA

Penetrating trauma to the penis is most often caused by firearms but can also result from stab wounds, industrial accidents, self-mutilation attempts, and bites. In all cases, general principles of management include judicious debridement and hemostasis within the wound as well as careful exploration and repair of corporal and urethral injuries. Most civilian penile gunshot wounds are caused by low-velocity missiles, which cause damage only in the path of the bullet. Penetrating penile injuries are a more common genitourinary injury during wartime, possibly because of inadequate genital coverage by protective body armor and are a result of high-velocity missiles or explosive devices (20,21). Associated wounds of the thigh and pelvis are common and may require urgent exploration and repair. Successful treatment of penetrating penile injuries must address and preserve normal voiding, potency, and penile cosmesis.

Diagnosis

Genital injury is determined by careful physical examination, with special attention paid to the trajectory of the bullet and initial hemostasis. The finding of a palpable corporeal defect in combination with an expanding penile hematoma or significant bleeding from the entry/exit wound is highly predictive of corporeal injury and should prompt expedient exploration (22). The exam should include a vascular (glanular capillary refill) and penile sensory assessment (9). Urethral injury, which occurs in 25% to 40% of penetrating injuries to the penis, should be excluded with an RUG in all cases (23). The absence of blood at the meatus, absence of hematuria, and normal voiding suggests that there is no urethral injury; however, penetrating trauma can cause urethral injury without clinical signs of damage. Cystography, intravenous pyelography, and scrotal ultrasonography may be necessary to evaluate associated urologic injuries. Cavernosography is rarely indicated in this setting (9).

Indications for Surgery

Penetrating injury to the penis most often requires surgical exploration. In addition, patients with unstable major organ injury will be unable to undergo immediate exploration. In these cases, initial treatment consists of hemostasis and packing of major wounds. Penetrating injury causing major skin loss will require tissue transfer for satisfactory coverage, but associated corporal and urethral injuries must be repaired before the skin grafting. In addition, ballistic injuries need judicial tissue debridement prior to reconstruction, which may require several trips to the operating room as the nonviable tissue declares itself over time (20). Immediate primary closure or reconstruction should take place only with a clean wound that is in general less than 8 hours old.

Alternative Therapy

Single pellet wounds with small entrance sites and superficial stab wounds in which there is no active bleeding or hematoma may not require surgical exploration (3).

Surgical Technique

The operation consists of judicious debridement of devitalized tissue and hemostasis. The wound must be copiously irrigated to remove all foreign bodies, including powder from shotgun pellets and pieces of clothing. Bleeding almost always occurs from a lacerated corporal body but may also be from disrupted superficial veins. The primary objective of surgical exploration is control of corporal bleeding and repair of corporal defects. The corpora are well vascularized, and extensive debridement is usually unnecessary and will hinder future potency. We thus do not recommend extensive exploration of erectile or glanular tissue. Hemostasis is obtained by gentle compression and watertight closure of the tunica albuginea alone, usually with interrupted 4-0 synthetic, absorbable, monofilament sutures. Urethral injuries are repaired with 5-0 absorbable, synthetic, braided sutures over a silicone catheter. A devitalized urethra must be carefully debrided, and primary repair with a tension-free anastomosis can usually be accomplished (Fig. 71.8A and B).

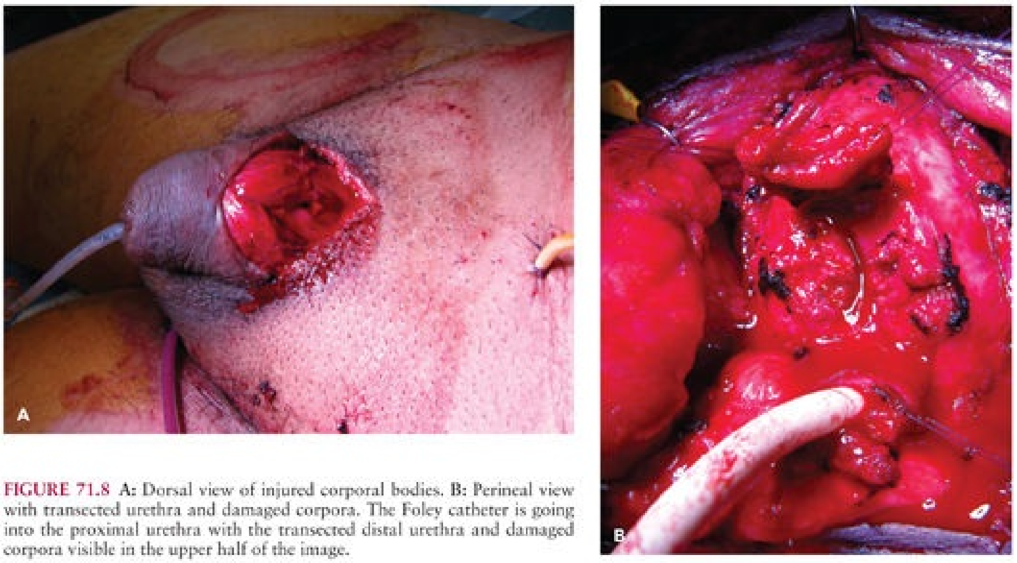

FIGURE 71.8 A: Dorsal view of injured corporal bodies. B: Perineal view with transected urethra and damaged corpora. The Foley catheter is going into the proximal urethra with the transected distal urethra and damaged corpora visible in the upper half of the image.

Associated scrotal and spermatic cord injuries are treated with debridement and, if necessary, orchiectomy or ligation of the vas deferens. The skin can be closed primarily unless viable skin edges cannot be approximated. In contaminated wounds or those encountered after 8 hours, immediate skin closure or grafting is not recommended and the wound is packed instead and managed with frequent wet-to-dry dressing changes. Once the wound is clean, delayed primary closure, staged reconstruction, or healing by secondary intention may be selected. An important contraindication to debridement and primary closure is the case of massive tissue destruction often associated with close-range shotgun blasts. These should be debrided and allowed to declare themselves in terms of the extent of injury. They may then be repaired in a staged fashion. It appears that longer range injuries due to shotgun blasts may create multiple low-velocity wounds with less significant blast effect. Carefully selected longer range shotgun injuries have been successfully managed with immediate debridement and primary repair (24).

Penile bites deserve special mention as they can rapidly progress to severe infection. Wounds should be copiously irrigated and all devitalized tissue debrided. All wounds should be left open and prophylactic antibiotics administered. Antibiotic treatment should cover gram-positive and gram-negative organisms as well as anaerobic gram-negative rods. The most common colonizing organisms in the mouth of a dog include *Pasteurella*, *Streptococcus*, and *Staphylococcus* species (25). Hospitalization with frequent wound inspection and intravenous antibiotics is necessary in those with delayed presentation or with increased risk factors such as steroid use, diabetes, or immunodeficiency syndromes. Close follow-up is mandatory in all outpatients.

Outcomes

Complications

Early complications of penetrating penile trauma include rebleeding and infection. Because the corpora are heavily vascularized, breakdown of repair in the tunica albuginea is rare. A small minority will report superficial sensory loss, pain with erection, and rapid detumescence. Complications attributable to the urethral injury include urethral stricture, periurethral abscess, and urethrocutaneous fistula.

Results

Excellent functional results can be expected except in those cases of high-velocity injuries where massive tissue destruction has occurred. Most patients report retained potency without penile curvature and with satisfactory cosmetic results (26,27). Patients who develop late penile curvature in the absence of palpable corporeal defects or plaques may have scarring and contraction of the underlying cavernosal tissues and the intercavernous septum (22).

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CHAPTER 72 ■ PENILE REPLANTATION

JAIRAM R. ESWARA AND STEVEN B. BRANDES

Penile amputation is a rare condition that may be life-threatening if the bleeding is not controlled early. In addition to the physical injury, the psychological injury can be devastating. Phallic injuries have been reported in both children and adults and arise largely from attempts at self-emasculation among psychiatric patients, assault, workplace injury, circumcision, or during war (1–4).

The first penile replantation was described in 1929 by Ehrich (5) from Evansville, Indiana. He described a patient whose penis had been severed with a circular saw. The penis was reattached using no. 1 plain gut for the urethra and no. 1 chromic gut for the corpora cavernosa, and the patient had adequate erectile function at time of follow-up. The advent of microvascular techniques led to the first such repair by Cohen et al. (6) from Massachusetts General Hospital in 1977, and this is now the standard of care. Their technique involved approximating the urethra, corpora, and microsurgical anastomosis of the dorsal vein, arteries, and nerves. To date, there have been approximately 100 reports of penile replantation, both microsurgical and nonmicrosurgical, in the literature.

The largest single series of penile amputation injuries comes from Thailand, where 100 cases were reported, 18 of which underwent nonmicrosurgical anastomosis using the technique described by McRoberts (anastomosis over Foley catheter with scrotal tunneling of the denuded shaft) (7,8). Stabilizing the patient hemodynamically and psychiatrically is critical in the acute setting. The hemorrhage can be severe and has led to death in several instances; therefore, aggressive fluid resuscitation and blood transfusion may be necessary.

The physical diagnosis is obvious with complete loss of the distal penis. Given the high rate of command psychoses and severe personality disorders in this group, the surgery staff must work closely with a psychiatrist. Traumatic amputations either from an assault or industrial equipment will also likely have a postsurgical need for psychiatric evaluation.

The act of self-mutilation during psychosis is known as Klingsor syndrome after the magician who castrates himself in Wagner's opera *Parsifal*. Psychotic patients who carry out self-emasculation are typically schizophrenic. One study found that 87% of self-emasculating patients were psychotic at the time of injury (4). These patients are usually victims of command hallucinations that coerce the patient to mutilate his genitals. Nonpsychotic patients who self-emasculate are often diagnosed with severe personality disorders. These patients are more difficult to rehabilitate.

PRESERVATION OF SEVERED PENIS

The severed penis should be cleansed and gently debrided using normal saline. It should then be wrapped in damp saline dressings and kept cool by a separate ice compartment using the "bag-within-a-bag" technique. Placing the phallus directly on ice can lead to tissue edema and necrosis.

Technique

There are three ways to manage the amputated phallus: surgical replantation of the amputated penis, reconstruction of the remaining stump, and total phallic replacement. If the amputated penis is viable, penile replantation should be attempted. The penis should always be reimplanted because psychotic patients are typically remorseful after self-emasculation. If a patient experiencing psychosis refuses treatment, repair should still be attempted after competency has been determined.

Because penile tissue has a remarkable resistance to prolonged ischemia, all attempts to replant the penile remnant should be carried out unless the penis has been extremely mutilated. As successful replantation has been reported after 16 hours of cold ischemia and 6 hours of warm ischemia, penile replantation may be attempted up to 24 hours or longer after the injury (9).

Viable Penis for Replantation

To perform replantation, the initial surgical step is to obtain vascular control of the proximal edge of each corpus (Fig. 72.1). Depending on the extent of the bleeding, manual compression with gauze or a Penrose drain tourniquet may be necessary. After the bleeding is controlled, the tunica albuginea of the corpora cavernosa are reapproximated with 3-0 polyglactin (Vicryl) suture including suturing of the median septum for stabilization. The central cavernosal arteries do not need anastomosis because this is both technically very difficult and does not improve outcome (10). The proximal and distal urethral edges are mobilized off the corpora and the ends spatulated. The urethra is then anastomosed over a 16Fr silicone Foley catheter in the same manner as an anastomotic urethroplasty (Fig. 72.2). A two-layer closure is usually performed with interrupted 4-0 polydioxanone or Vicryl sutures soaked in mineral oil. A suprapubic tube is typically also placed to divert urine. In this way, the penile Foley may be capped.

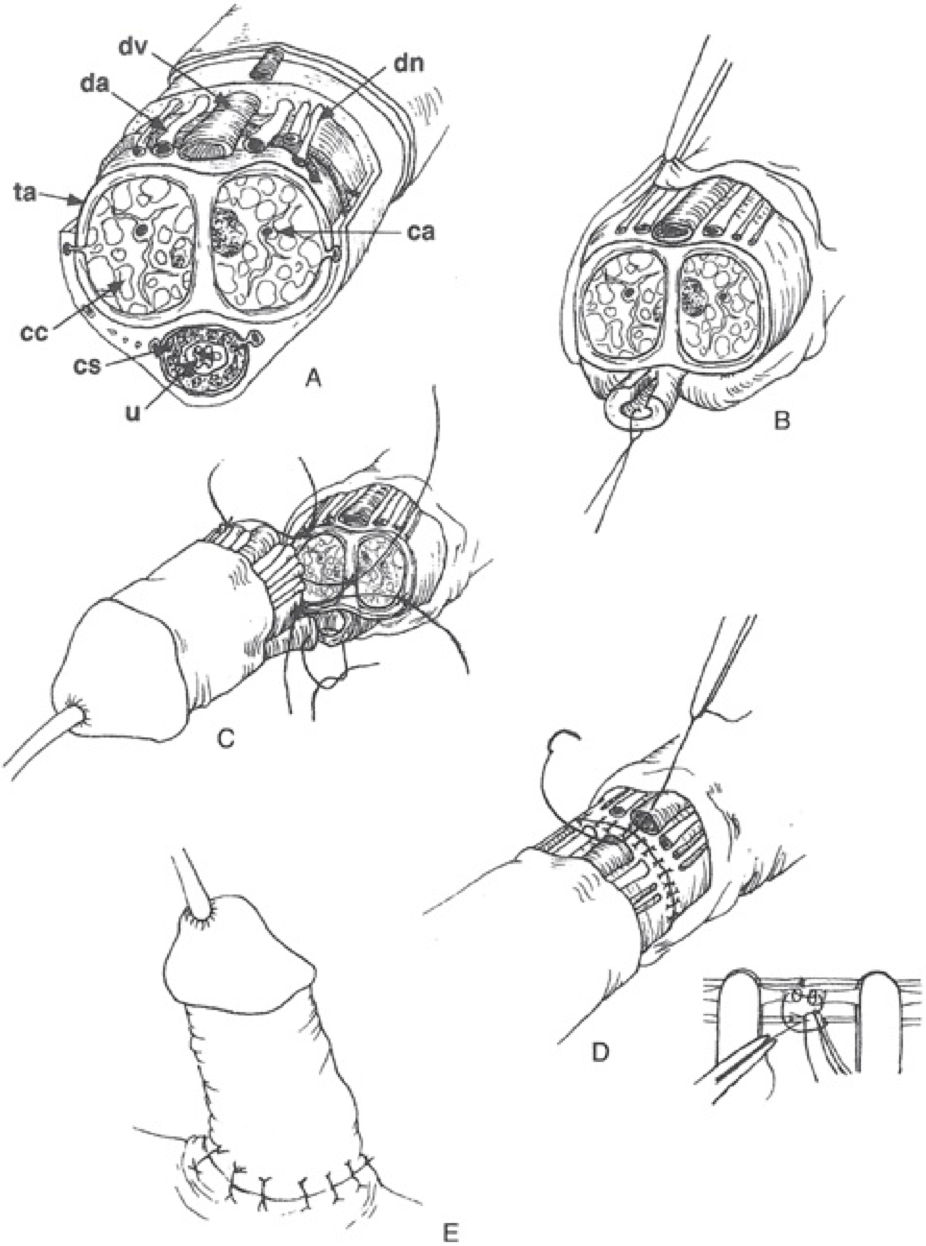

FIGURE 72.1 Penis amputation. **A:** Cross-sectional anatomy of penile stump. **B:** Exposure of the dorsal vessels/nerves and spatulation of the urethra. **C:** Reanastomosis of the corpora, median septum, and urethra. **D:** Microvascular repair of the dorsal vessels. **E:** Completed reattachment. *ca*, cavernous artery; *cc*, corpus cavernosum; *cs*, corpus spongiosum; *da*, dorsal artery; *dn*, dorsal nerve; *dv*, dorsal vein; *ta*, tunica albuginea; *u*, urethra. (Reprinted with permission from Rutchik SD, Seftel AD. Traumatic injury to the penis. *Urol Clin North Am* 1998;6(2):97–118. Copyright © 1998 Elsevier Inc.)

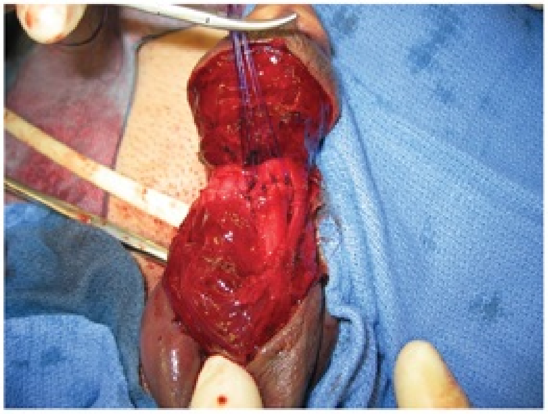

FIGURE 72.2 Repair of transected urethra by primary anastomosis (note interrupted sutures).

Once the penis is stabilized, microscopic anastomosis of the dorsal vessels and nerves is performed. First, the deep dorsal vein is anastomosed with 11-0 nylon or polypropylene (Prolene); this anastomosis must be patent to prevent glans and corporal edema. Second, one of the dorsal arteries, but preferably both, is reapproximated in the same manner as the vein. The arterial anastomosis restores blood flow to the subcutaneous tissues and helps prevent postoperative skin necrosis. Finally, the epineurium of the dorsal nerves is reapproximated with a simple 10-0 nylon or Prolene suture. The autonomic cavernous dorsal nerves do not demand repair. Reapproximation of the nerves is suggested to help preserve penile and skin sensation, however.

Depending on the state of the amputated penile skin, interrupted 4-0 chromic sutures may be used to reapproximate the skin edges. If the penile skin is unusable or extensively denuded, a nonmeshed, split-thickness skin graft is placed. Shaft skin should be preserved with minimal debridement because skin that initially appears dusky may improve during the postoperative period.

Nonsalvageable Amputated Penis

If the amputated penis is not viable or cannot be located, then the remaining penile stump is then assessed for functionality and possible reconstruction. The length of the residual penile stump will dictate the method of subsequent reconstruction. In general, we use the cutoff of 4 cm flaccid or 7.5 cm stretched length as the minimum length of penis needed to have satisfactory vaginal penetration intercourse. When the penile stump is of sufficient length, the denuded corpora are covered with a split-thickness skin graft, from the tip of the neoglans to the mobilized shaft skin and the distal urethral spatulated.

If the remaining penile stump is short (<4 cm), the penis can be advanced by dividing the suspensory ligament improving penile length by up to 2 to 3 cm. The mobilized penis is then resutured to the pubic bone with nonabsorbable braided suture (e.g., Ethibond). The residual shaft skin is then sutured to the proximal shaft, and the distal denuded corpora covered with a split-thickness skin graft. An alternative method for skin coverage is the transfer of superior lateral scrotal myocutaneous flaps or to bury the penis in a subcutaneous tunnel in the scrotum. This method leads to a suboptimal, hair-bearing, thick-skinned penile shaft and requires a second reconstructive surgery (8,11). Regardless of the method, covering the vascular anastomoses is important to prevent delayed vessel thrombosis and resulting replantation failure. Finally, the penis is wrapped in loose dressings and an external splint (a “penis house”) is fashioned to encourage venous and lymphatic drainage.

If a patient does not have access to a medical center with microsurgical capabilities, then reattachment involving simple reapproximation of the urethra and corpora can be attempted. Anastomosis of the deep dorsal vein alone is technically simpler than anastomosis of the dorsal arteries and leads to less glans hyperemia. Given its relative technical ease, this can be performed using loupes, and a microscope is not necessary (12). If penile replantation is not an option, then the penile stump can be closed as done for a standard elective partial penectomy (Figs. 72.3 and 72.4). A phalloplasty can be performed at a later date.

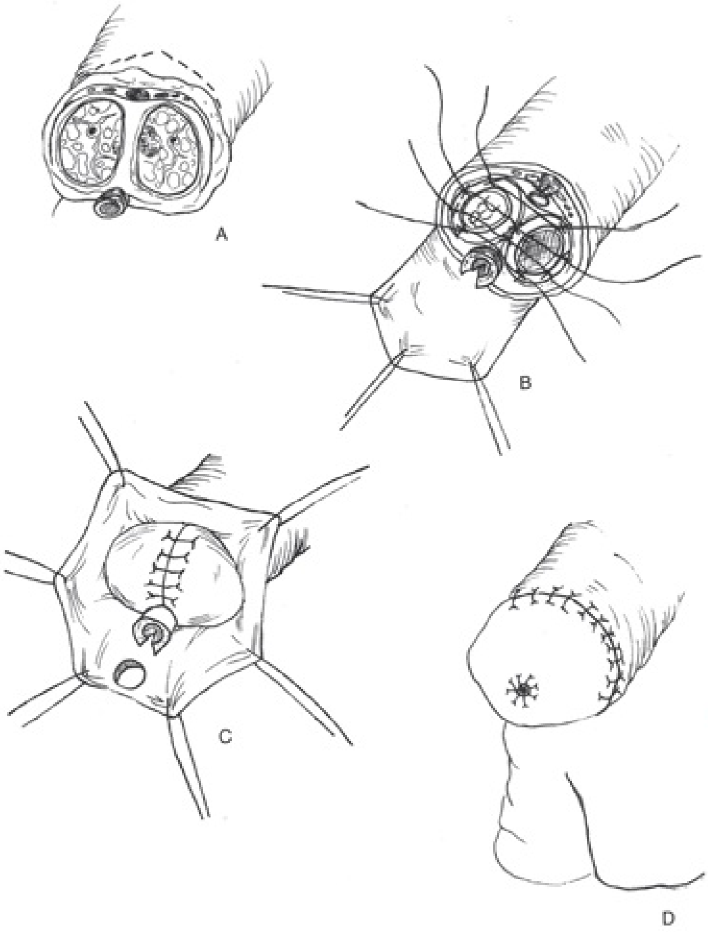

FIGURE 72.3 Amputation and loss of dismembered penis. **A:** Amputated penile stump. **B:** Closure of the corpora, ligation of the dorsal vessels, and spatulation of the urethra. **C:** Mobilization of the penile skin flap. **D:** Completed coverage of the partial penectomy and urethral anastomosis. (Reprinted with permission from Rutchik SD, Seftel AD. Traumatic injury to the penis. *Urol Clin North Am* 1998;6(2):97–118. Copyright © 1998 Elsevier Inc.)

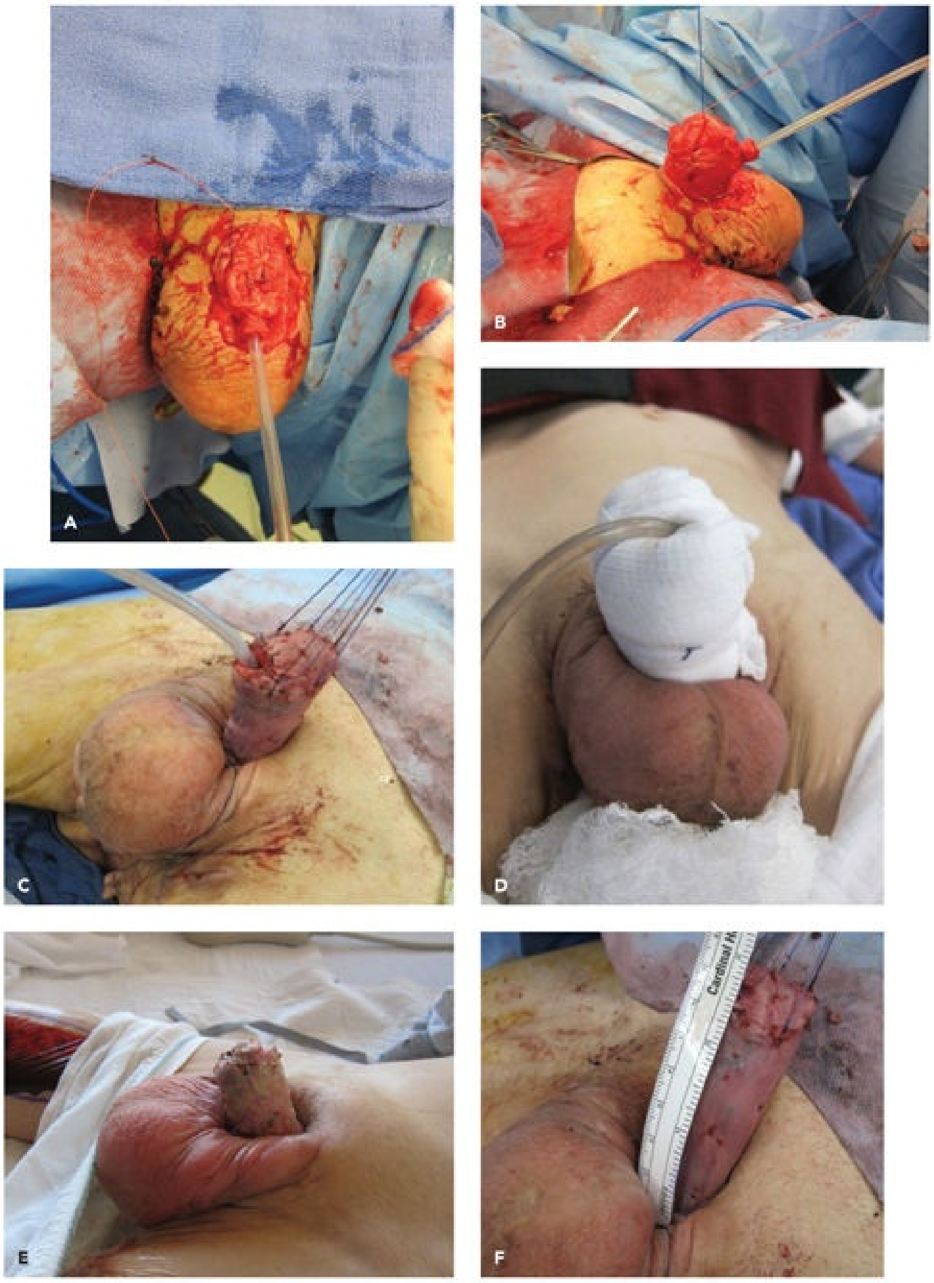

FIGURE 72.4 Residual short stump after penile amputation. **A and B:** Reconstruction by penile advancement and suspensory ligament release. **C:** Split-thickness skin grafting. **D:** Bolster dressing, colloquially known as a "penis house." **E and F:** Penis at postoperative day 5, note excellent graft take and 7 cm penile length.

Total phallic reconstruction may be considered in order to improve body image and psychosexual identity, particularly in younger men. Reports of phallic reconstruction after amputation are rare and typically employ a radial forearm free flap (13). The technical aspects of creating a neophallus after penile amputation are very similar to that for a female-to-male gender reassignment operation. Chang and Hwang (14) first described a forearm free flap based on the radial artery for phallic reconstruction. The major advantages of this flap are it is reliable, sensate, has a predictable anatomy, reliable vascular supply, and pliable skin (14,15). Major disadvantages are the donor site scar and deformity of the nondominant arm, complexity of the surgery, and the high complication rates, particularly urethral stricture.

POSTOPERATIVE MANAGEMENT

Postoperative management should include at least 2 to 5 days of bedrest, perioperative broad-spectrum antibiotics, and the use of Doppler ultrasonography to ensure graft survival. After 2 weeks of urethral stenting, the Foley may be removed after a pericatheter retrograde urethrogram performed to demonstrate no urethral leak. The suprapubic tube can be removed after a few days of normal voiding. Besides surgical management, psychiatric care must be ongoing. Genital self-mutilation is an irrational act, and there is a higher suicide rate among this population. Once the psychotic episode has been treated, most patients are remorseful and regret the act of self-mutilation. Of patients who have committed self-emasculation during psychosis, 31% will repeat this type of injury, typically after having discontinued medications (16).

OUTCOMES

Given the uniformly favorable results of microvascular penile replantation from both a cosmetic and functional perspective, this approach should be used if at all possible. If microsurgery is not feasible, macroscopic replantation should still be offered because this still offers reasonable success.

A recent systematic review was performed by Babaei and Safarinejad (17) in 2007. They found 50 cases of nonmicrosurgical replantation and 30 cases of microsurgical replantation after 1984. They reported a 90% (27/30) success rate among microsurgical repairs as defined by organ viability. They concluded that venous outflow was critical to long-term success.

Although the rate of erectile function after nonmicrosurgical repair, that is, anastomosis of only the deep dorsal vein, is approximately 80%, this technique is associated with a higher rate of fistula formation, urethral stenosis, glans and skin necrosis, loss of sensation, and erectile dysfunction (7).

COMPLICATIONS

The most common complications of penile replantation include skin sloughing, glans ischemia, erectile dysfunction, and urethral stricture and fistula (7,18). Although common, lymphedema and venous congestion are generally self-limiting. Microsurgical approaches have reduced the rates of these complications.

Partial or complete erections following microvascular replantation are common (19,20). Patients who fail to achieve adequate return of erections may still respond to vasodilatory pharmacologic therapy (e.g., prostaglandin E1 [Alprostadil], alprostadil/papaverine/phentolamine [Trimix]).

Once surgically reattached, adjuvant therapies have been reported to promote penile preservation. Leech therapy has been used with success, likely owing to improvement in decreased venous congestion (21,22). Hyperbaric oxygen has also been used in conjunction with microsurgical repair with successful outcomes (23).

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CHAPTER 73 HYDROCELE AND SPERMATOCELE

ALI A. DABAJA AND CIGDEM TANRIKUT

HYDROCELE

Hydroceles were described as early as the 16th century by the French surgeon Ambroise Paré and refer to an abnormal collection of serous fluid between the parietal and visceral layers of the tunica vaginalis. They are the most common cause of painless, nonacute scrotal swelling, with an estimated incidence of 1% in the adult population (1) and are more commonly seen after the age of 40 years.

Embryology and Etiology

In order to understand how hydroceles form, one must understand the embryologic origin of the inguinal canal and the process of testicular descent. As the testis develops, it is anchored by two ligaments, the cranial and the caudal suspensory ligaments. The caudal suspensory ligament, also known as the gubernaculum, fixes the testis within the scrotum and directs its course during descent. At approximately the seventh week of development, shortening of the gubernaculum pulls the testis from the level of the 10th thoracic vertebra through the inguinal canal and toward the scrotum. As the gubernaculum shortens, its most ventral peritoneal cover invaginates to develop a semicircular blind-ending cavity, known as the processus vaginalis. The growth of the processus vaginalis is directed inferiorly and drags the various layers of the abdominal wall with it, leading to the formation of the inguinal canal (2).

Testicular descent is divided into two phases: the intra-abdominal phase and the inguinal-scrotal phase. During the intra-abdominal phase between the 7th and 12th weeks of gestation, the gubernaculum shortens and pulls the testis down to the level of the deep inguinal ring. The testis remains in the vicinity of the deep ring until the seventh month of gestation then, in response to multiple factors including hormonal changes, the inguinal-scrotal phase begins and the testis descends through the inguinal canal and into the scrotum by the ninth month of gestation. Just before term delivery, the testis has completely entered the scrotum, and the gubernaculum has atrophied to a ligament that attaches the lower pole of the testis to the scrotum.

As the testis descends and the processus vaginalis develops, each layer of the abdominal wall contributes to the spermatic cord. The first layer encountered by the processus vaginalis is the transversalis fascia—this layer will become the internal spermatic fascia of the spermatic cord. Because the transversus abdominis muscle is not completely developed near the inguinal canal, this layer does not contribute to any of the layers. Next, the processus vaginalis pulls the fascia of the internal oblique muscle with it, which becomes the cremasteric fascia of the spermatic cord. Finally, the processus vaginalis evaginates into a thin layer of external oblique muscle, which becomes the external spermatic fascia (3) (Fig. 73.1).

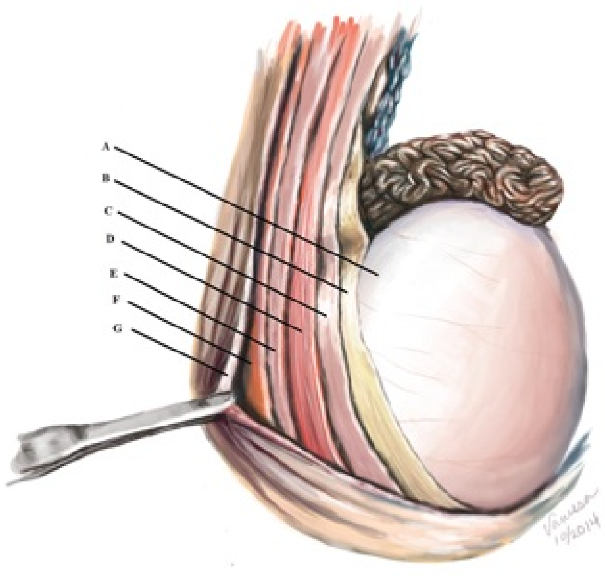

FIGURE 73.1 Anterior view of testis detailing the layers of the scrotum and their embryologic origins: (*A*) visceral tunica vaginalis, (*B*) parietal tunica vaginalis, (*C*) internal spermatic fascia, (*D*) cremaster muscle, (*E*) external spermatic fascia, (*F*) dartos layer, and (*G*) skin.

The processus vaginalis surrounds the testis to form the visceral and parietal layers. After testicular descent, the proximal end of the processus vaginalis located within the inguinal canal normally seals, leaving a small patent remnant surrounding the testis called the tunica vaginalis. If the proximal aspect fails to seal (patent processus vaginalis), communication between the tunica vaginalis and the abdominal cavity remains, and the tunica vaginalis will fill with serous fluid leading to formation of a communicating hydrocele. In some instances, the communication may be large enough to allow development of an indirect hernia (Fig. 73.2). A patent processus vaginalis is the most common cause of hydrocele in the pediatric population and usually resolves spontaneously by 18 to 24 months of age (4).

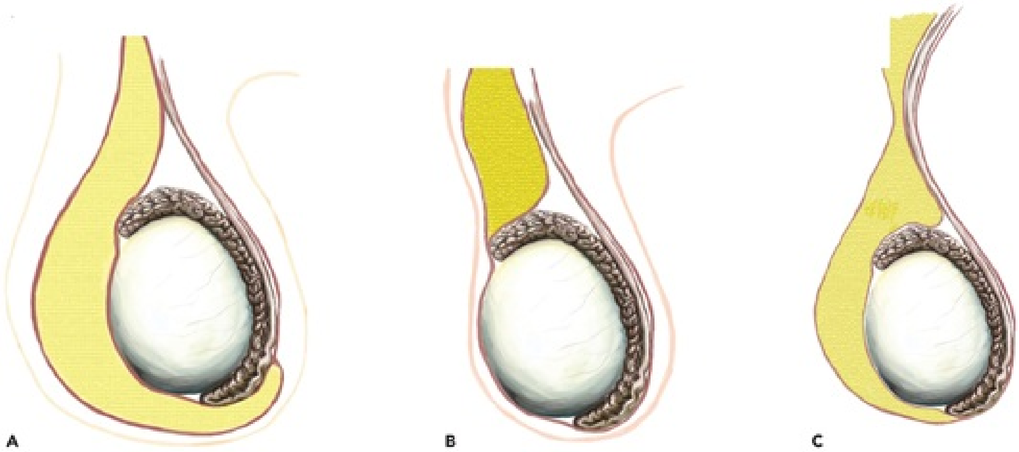

FIGURE 73.2 Types of hydrocele: (A) noncommunicating hydrocele, (B) hydrocele of the cord, and (C) communicating hydrocele.

Hydroceles in the adult population are generally acquired, noncommunicating hydroceles in which serous fluid accumulates within the tunica vaginalis. In the majority of cases, they are idiopathic (1), caused by either excess fluid production or inadequate drainage of fluid. Oversecretion of fluid may occur in response to infection or inflammation (e.g., orchitis), tumor (e.g., testicular cancer), obstructing testicular lymphatics, or trauma to the scrotum or inguinal canal. Inadequate drainage may develop as a result of prior inguinal or pelvic surgery. For example, one common cause of acquired hydrocele is nonmicrosurgical varicocelectomy (5) in which cord lymphatics, present in abundance within the sheath of the internal spermatic veins, are ligated along with the veins. Other surgical procedures such as inguinal hernia repair and renal transplant have been associated with hydrocele development. In addition, infection may cause lymphatic obstruction, such as in patients with the nematode parasitic infection *Wuchereria bancrofti* and, more commonly, severe or recurrent epididymitis or orchitis.

Diagnosis and Preoperative Patient Preparation

The normal scrotum contains 2 to 3 mL of fluid between the tunical layers with continuous production and drainage maintaining this volume at equilibrium. Sonographically detected hydroceles have been reported in as many as 65% of healthy men (6). The volume at which tunica vaginalis fluid becomes a hydrocele is not clearly defined. Even in cases of an obvious hydrocele on physical examination, the amount of fluid can be extremely variable among patients and may range from small and soft to large and tense.

Most commonly, patients present with complaints of painless swelling in one or both sides of the scrotum, occasionally reporting a vague scrotal pain or sensation of heaviness. Men may seek evaluation due to scrotal discomfort during intercourse or physical activity, anxiety in regard to the cosmetic appearance of the scrotum, concerns about damage to the reproductive organs, or fear of malignancy. Cases of painful and acute-onset hydrocele are usually secondary to trauma, infection, or testicular torsion and should be investigated promptly.

In the pediatric population, the parent may report that the degree of scrotal swelling fluctuates in size, often noting enlargement of scrotal swelling with increased abdominal pressures, such as during crying episodes. This finding usually suggests a patent processus vaginalis.

The diagnosis of hydrocele is made clinically by appreciating fluid around the testis, and one can usually transilluminate the scrotum. In patients with long-standing hydroceles in which the tunica vaginalis is thick, highly inflamed, and fibrotic, the fluid collection may fail to transilluminate. In all cases of suspected hydrocele, especially when the testis cannot be palpated due to the size of the hydrocele, an ultrasound is warranted to confirm the diagnosis and to rule out testicular lesions suspicious for malignancy (7). Additional investigations, such as complex imaging, are generally not required. It is important to assess for presence of a patent processus vaginalis or a concomitant inguinal hernia, as an inguinal approach would be appropriate for hydrocele repair in such circumstances. An inguinal approach is also necessary when neoplasm is suspected on scrotal ultrasound but not definitively diagnosed preoperatively.

Indications for Treatment

Hydroceles can cause discomfort and embarrassment due to size and may have a negative impact on work performance, sexual function, and daily activity, particularly in patients with advanced lymphedema and large hydrocele caused by lymphatic filariasis (8). Treatment is indicated when the patient complains of discomfort or disability due to size of the hydrocele. Data are scarce related to the possible effect of hydrocele on testicular function. It has been postulated that hydrocele may act as an insulator, leading to an increase in scrotal temperature with a possible subsequent negative impact on spermatogenesis (9). Tense hydroceles may cause pressure atrophy of the testis and increase the resistive index of the subcapsular artery (10).

Treatment

The basic principles of any hydrocele treatment are drainage of excess fluid and prevention of fluid reaccumulation (11). Surgery via a scrotal approach is the gold standard for repair of most adult hydroceles; fluid is drained after opening the tunica vaginalis and then the tunica is either excised, plicated, or inverted behind the cord in a bottleneck fashion. In the pediatric population, the presence of a patent processus vaginalis or an inguinal hernia will require an inguinal approach. An inguinal approach is also necessary when attendant neoplasm or hernia is suspected preoperatively. This allows for inspection of the testis to identify any potential testicular malignancy and to taking safe and appropriate action to manage such a situation, such as clamping the spermatic cord and carrying out testicular biopsy, if necessary. If the suspicious lesion is benign, the remaining testis is then reduced into the scrotum or, in the case of malignancy, a radical orchiectomy can be performed (12). Patients must be informed preoperatively of potential complications including scrotal hematoma, infection, testicular atrophy or injury, hydrocele recurrence, and fertility alterations.

Nonsurgical Repair

If the clinician believes that the hydrocele is due to an acute process and that the imbalance between fluid production and reabsorption may be temporary, as in an episode of orchitis, observation is a viable treatment option. Active surveillance is also recommended in children younger than the age of 2 years with a congenital hydrocele unless the patient has an accompanying hernia or if the diagnosis is uncertain, as many of these communicating hydroceles will resolve within the first 2 years of life if managed conservatively.

In patients who are poor surgical candidates, the hydrocele fluid can be aspirated percutaneously and sclerotherapy can be performed in an effort to eliminate the potential space. Hydrocele aspiration and sclerotherapy was first reported in 1975 as a nonsurgical outpatient treatment for acquired hydroceles as an attempt to address complications related to hydrocelectomy. Moloney (13) reported using a mixture of phenol, glucose, and glycerine as a sclerosing agent. Since then, multiple chemical and pharmacologic agents have been employed, including, but not limited to, 99.5% alcohol, antazoline, talc, ethanolamine oleate, tetracycline, fibrin glue, blood, phenol, and sodium tetradecyl sulfate (STDS). In addition to the many agents that have been used, various techniques have also been described, resulting in outcomes that are difficult to interpret and compare. In a recent trial, hydrocele aspiration and sclerotherapy with doxycycline corrected 84% of simple hydroceles within a single treatment. The use of doxycycline showed a better success rate as compared to other sclerosing agents and a similar outcome to the reported success rates of hydrocelectomy (14).

Aspiration and instillation with sclerosing agents should never be employed in men where future fertility may be a concern because obstruction of the epididymis is a significant risk of this technique (15). Furthermore, when this method fails, subsequent surgical hydrocelectomy is much more difficult due to adhesions and formation of multiple loculations.

Percutaneous aspiration and sclerotherapy can be performed in an outpatient office setting with local anesthesia. All patients are screened with a scrotal ultrasound to determine the nature of the hydrocele and to rule out scrotal abnormalities including testicular malignancy, spermatoceles, and septations. The hydrocele can be transilluminated with a light source, or ultrasound can be used to allow visualization of the hydrocele sac. Maintaining the hydrocele under pressure is important in an effort to avoid testicular injury. After initiation of a spermatic cord block, complete aspiration of the hydrocele can be performed using a 16- or a 19-gauge butterfly needle attached to a three-way stopcock; this allows the clinician to aspirate the hydrocele fluid then instill the sclerosing agent via the same puncture site. After complete drainage of the hydrocele fluid, the sclerosing solution is injected and a supportive dressing is applied (14,16).

Surgical Repair

Patient Preparation

There are several surgical approaches to accomplish hydrocelectomy. The procedure may be performed under general, spinal, or, less commonly, local anesthesia. Administration of preoperative antibiotics is appropriate, whereas postoperative antibiotics are generally not indicated. The scrotum and penis are shaved and the entire area is prepped and draped in a sterile fashion. The approach can be via either a median raphe incision, which gives ready access to both sides of the scrotum, or a transverse incision within the scrotal skin folds, avoiding the blood vessels (Fig. 73.3). The incision is carried down through the dartos fibers to the level of the tunica vaginalis where the characteristic “Robin egg blue” of the hydrocele is seen. At this point, one may select with which procedure to proceed.

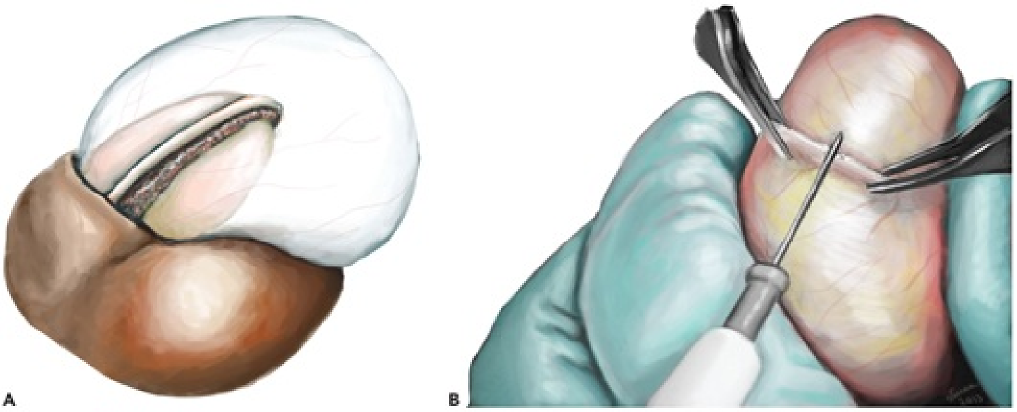

FIGURE 73.3 A: Testis within the hydrocele sac is exposed through a small skin incision. Depending on the repair technique employed, the tunica vaginalis is opened (B), and the testis and epididymis are delivered.

Jaboulay Procedure

Described by Mathieu Jaboulay in 1902 (17) (also called the Winkelmann procedure), this method involves making an incision in the tunica vaginalis through which the hydrocele fluid is drained. The testis is delivered through the incision and then most of the hydrocele sac is resected, leaving a small cuff along the borders of the testis and the epididymis. The remnant is everted posteriorly and the tunical edges are reapproximated in a running fashion (Fig. 73.4). Care must be taken to ensure that the closure is loose enough that the spermatic cord is not constricted (18). A modified version of this technique involves resecting the tunica vaginalis nearly flush with the testis and epididymis and either cauterizing the cut edges or oversewing them (Fig. 73.5). This approach runs an increased risk of injury to the epididymal and testicular blood supply. Use of loupes or, better yet, an operating microscope and leaving at least a 1-cm margin of sac minimizes the risk of epididymal vessel or testicular artery injury (19).

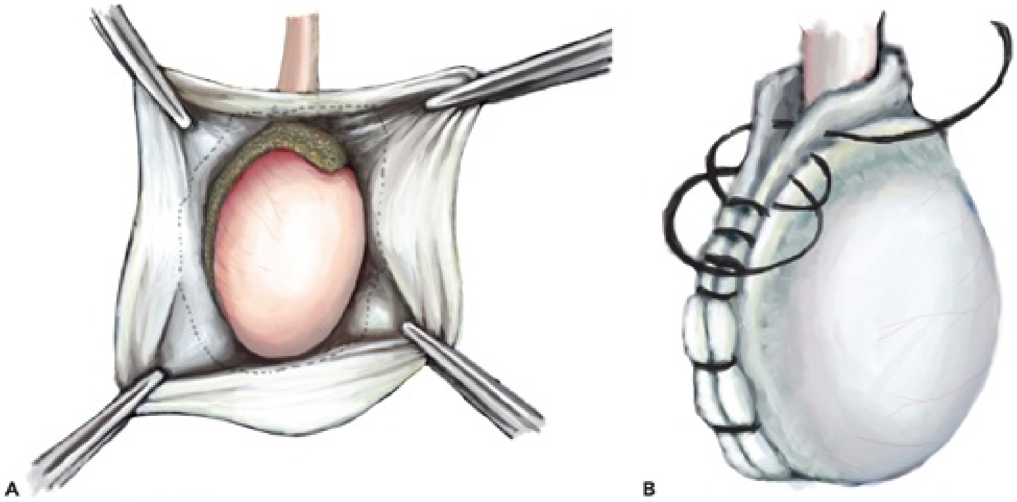

FIGURE 73.4 Jaboulay procedure. A: The hydrocele sac is resected, leaving a 1- to 2-cm cuff along the borders of the testis and epididymis. B: The edges are everted posteriorly around the cord and reapproximated by a running suture.

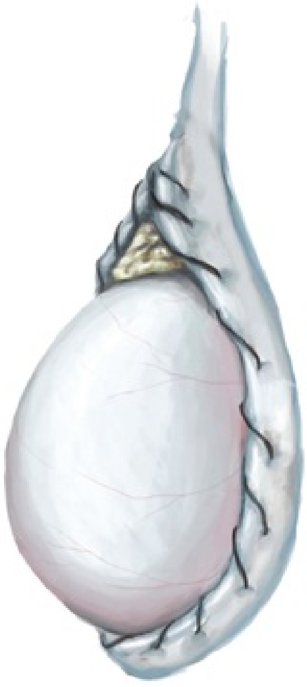

FIGURE 73.5 Modified Jaboulay: The tunica vaginalis is resected close to the edges of the testis and epididymis and the edges are oversewn.

The Jaboulay technique requires extensive dissection of the hydrocele sac that may lead to pain and scrotal edema. To minimize the dissection, a variant surgical procedure based on the same principle has been suggested (20): through a smaller (~15 mm) transverse scrotal incision, the tunica vaginalis is identified and grasped at the medial and lateral aspects of the incision. The sac is punctured to allow aspiration of the hydrocele fluid. Then, the tunica vaginalis is gently freed and delivered out of the small scrotal incision by applying gentle traction. After fully mobilizing and delivering the hydrocele sac, it is excised by electrocautery, and the wound is closed without the need to deliver the testis.

Andrews Procedure

This technique was described by E. Wyllys Andrews (21) in 1907 to improve the speed and the efficiency of the Jaboulay procedure. Andrews referred to this procedure in his original publications as the “bottle operation.” This works best with thin-walled, simple hydroceles without loculations. The testis is delivered through an anterior scrotal incision within the tunica vaginalis. The hydrocele sac is inspected and a vertical 2- to 3-cm incision is made in the anterior surface as it tapers into the cord. When the hydrocele fluid is drained, the empty sac takes on the shape of a bottle with an opening at its superior aspect. The testis is delivered through that superior tunical incision then the hydrocele sac is everted and the everted sac now surrounds the spermatic cord (Fig. 73.6). If there is any bleeding, the cut edge is sutured and appended around the cord. Otherwise, the everted edges of the sac can be left open without requirement of sutures.

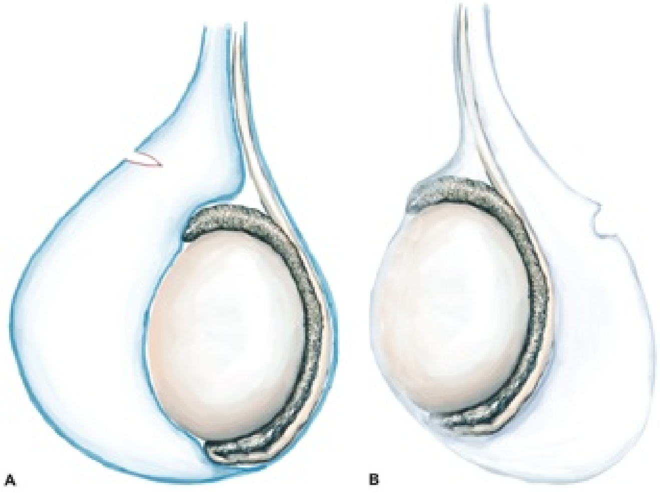

FIGURE 73.6 Andrews procedure. **A:** A 2- to 3-cm incision is made in the superior-anterior aspect of the hydrocele sac. **B:** The hydrocele sac is everted around the testicle resulting in relocation of the hydrocele incision posterior to the testis and around the cord; no sutures are required.

Lord Procedure

Peter Lord (22) devised a plication technique showing that several evenly spaced plicating sutures in the hydrocele sac can effectively obliterate the tunica vaginalis. As the plication technique includes minimal dissecting of the hydrocele sac, there may be relatively less bleeding intraoperatively and less scrotal swelling postoperatively as compared with other techniques. The hydrocele sac is opened, the fluid is drained, and the tunica vaginalis is minimally dissected off the dartos muscle. Allis clamps are used to hold the cut edges to visualize the testis and epididymis. After the hydrocele sac is completely opened, the edges are circumferentially plicated by placing interrupted sutures approximately 1 cm apart and 1 cm deep (Fig. 73.7). When tying these sutures, the hydrocele sac will fold onto itself, eliminating the sac. The suture placement for the Lord plication starts near the margin of the testis and the epididymis and thus carries an inherent risk of testicular or epididymal injury. When employing this for large, thick-walled hydroceles, considerable residual scrotal mass remains.

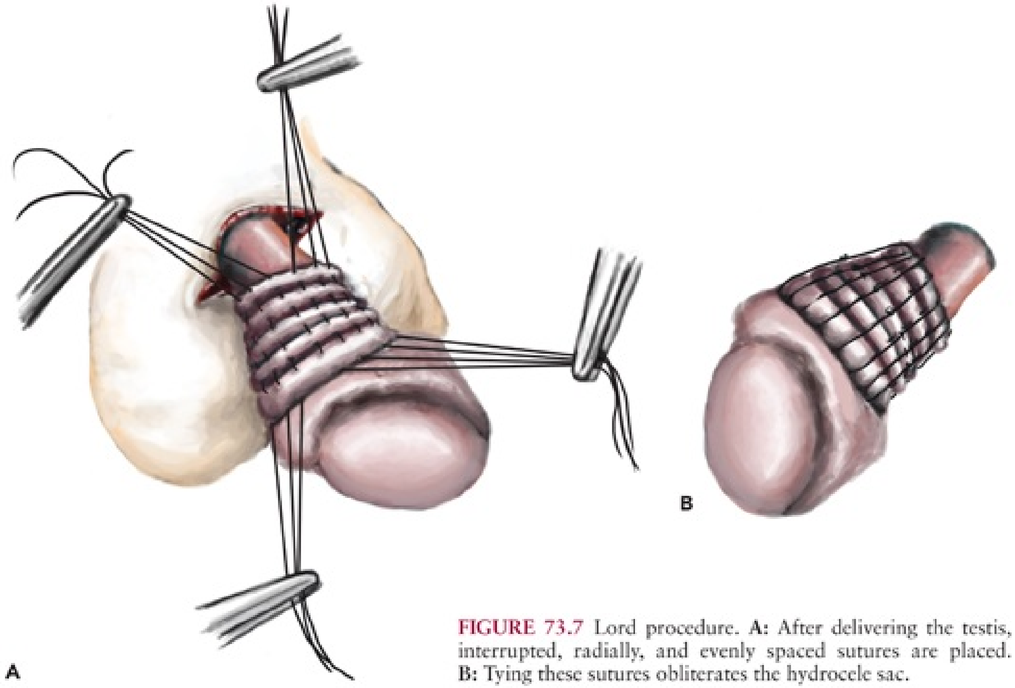

FIGURE 73.7 Lord procedure. **A:** After delivering the testis, interrupted, radially, and evenly spaced sutures are placed. **B:** Tying these sutures obliterates the hydrocele sac.

Recent publications describe combined plication and eversion techniques through a vertical incision on the scrotum. The hydrocele sac is dissected completely, the fluid is drained, and the hydrocele sac is everted. Using this modified technique, a plication suture of 3-0 chromic is placed 1 cm away from the testicular margin. The same suture is used to traverse posterior to the testis in order to plicate to the opposite edge of the sac at the same level, also about 1 cm away from the testicular margin. A maximum of three or four stitches are used, taken at different levels and placed about 1.5 cm away from each other. In this technique, fewer sutures are used as compared to Lord plication. These modifications make the procedure quicker and less likely to injure the epididymis (23).

Microsurgically Assisted Hydrocelectomy

This is now our preferred approach, especially in men where future fertility is an issue. Prior to surgery, a scrotal ultrasound should be performed to confirm absence of testis tumor. Through a transverse scrotal skin-fold incision, the hydrocele is delivered, and the spermatic cord and vas are identified and surrounded with a Penrose drain. An opening is made in the hydrocele sac, the hydrocele fluid drained, and the testis and epididymis delivered. Use of the operating microscope at the time of hydrocelectomy enables identification of the vas deferens, vassal vessels, and the epididymis, minimizing the possibility of iatrogenic injury. Transillumination of the opened hydrocele sac using the operating room lights can help identify the vas and epididymis, which may be splayed out within the walls of a thick and long-standing hydrocele sac and be difficult to otherwise identify. The vas should be dissected from the cord to the vasoepididymal junction. In cases where the margins of the epididymis are indistinct, the operating microscope is indispensable to assure that epididymal tubules are not transected during hydrocele sac excision. Redundant tunica vaginalis is resected, leaving a fingerbreadth margin of tunic around the epididymis. A bipolar cautery is used to control small bleeding vessels and larger ones are ligated or clipped. Although there is no published data available comparing the outcomes of microsurgical versus nonmicrosurgical hydrocelectomy, in our experience, microsurgical technique minimizes iatrogenic complications without significantly extending the operative time (24).

Wound Closure

After returning the testis to the scrotum in its proper anatomic orientation, an assessment of the surgical field for bleeding should be performed and meticulous hemostasis should be obtained. In large hydroceles, when the gubernacular has to be transected, the testis should be pexed with two or three interrupted sutures of 2-0 polydioxanone suture (PDS) from the cut edge of the hydrocele sac to the dartos to prevent torsion. Most hydrocelectomies may be performed without surgical drainage. However, it is important to note that the scrotal skin and fascial layers have little or no capacity to tamponade any bleeding. When hemostasis is difficult to obtain, a small Penrose drain should be placed through a separate stab incision in the dependent aspect of the scrotum and left overnight. The drain should be secured in place with 2-0 silk and a safety pin suture to prevent its migration into or out of the scrotum. The scrotal wound is closed in two layers using absorbable suture: the cut edges of the dartos muscle are closed with 3-0 Vicryl or Monocryl to prevent scrotal bleeding, then the skin is closed per the surgeon's preference (Fig. 73.8). Fluffed gauze held in place by an athletic supporter provides a supportive, compressive dressing. An ice pack helps diminish postoperative pain and swelling.

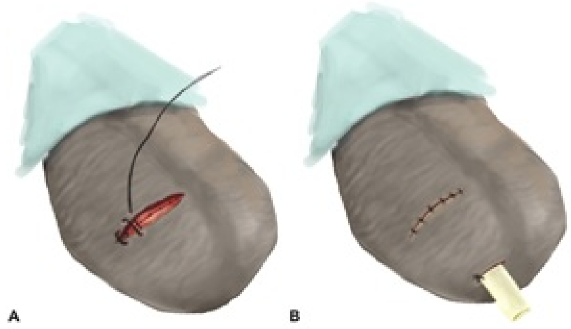

FIGURE 73.8 The testis is reduced into the scrotum and the incision is closed with two layers. A drain is placed in the dependent portion of the scrotum if hemostasis is not optimal.

Outcomes and Complications

The success rates of hydrocelectomy depend on the technique, ranging from 81% to 98% (25). Complications following hydrocelectomy include hematoma formation, infection, persistent or recurrent swelling, testis atrophy, reproductive tract obstruction, and chronic pain. Overall complications may be as high as 54% (25). One of the most detrimental complications to those patients who still seek fertility is the risk of epididymal injury, which may occur in up to 6% of patients who undergo hydrocelectomy (26). Epididymal injury can be avoided by considering the use of an operating microscope to optimize visualization of the epididymis and the vas deferens during resection of the hydrocele sac (19). Transillumination of thick-walled sacs after opening it often helps delineate the epididymis and vas, which can be between layers of the sac.

SPERMATOCELE

A spermatocele is a cystic dilatation of the efferent ductules, rete testis, or epididymal tubules (27). It is hard to differentiate between a spermatocele and an epididymal cyst clinically, although spermatoceles always arise from the cyst. Unlike spermatoceles, epididymal cysts do not arise from or communicate with efferent ductules. However, the approach for repair is the same for each entity. Definitive diagnosis of spermatocele is made intraoperatively by identifying sperm within the cyst fluid on a wet mount, whereas no sperm are identified with examination of fluid from an epididymal cyst. Spermatoceles/epididymal cysts have been identified in approximately 30% of asymptomatic patients undergoing scrotal ultrasound (28). Sonographic findings include a unilocular or, less commonly, multilocular, well-defined hypoechoic lesion, which sometimes demonstrates posterior acoustic enhancement. A spermatocele/epididymal cyst may contain low-level echogenic proteinaceous fluid, and cyst wall calcification may be present (29). The etiology of spermatocele is idiopathic, traumatic, or inflammatory. Epididymal duct obstruction, such as secondary to vasectomy, is thought to be associated with spermatocele formation, and spermatoceles are often associated with tubular ectasia of the rete testis.

Diagnosis and Presentation

Patients present with a discrete, usually asymptomatic, mass arising from the caput epididymis that is definitively outside of the testis. Diagnosis can be made with history and physical examination. Examination reveals a mass separate from and usually superior to the testis. When large enough, these cysts can be transilluminated. In most instances, imaging is not necessary; however, if the diagnosis is questionable, ultrasound can be used to confirm the diagnosis.

Indications for Treatment

Most spermatoceles do not require intervention but some spermatoceles can grow quite large leading to discomfort or cosmetic concerns. Occasionally, spermatoceles are associated with antisperm antibody formation, which can result in impaired fertility. Historically, spermatocelectomy was avoided in men desiring future fertility. However, use of an operative microscope during spermatocelectomy is an effective method to minimize risk of epididymal injury and resultant obstruction (30).

Surgical Technique

Patient preparation and surgical approach is identical to that for hydrocelectomy. A transverse incision within the scrotal skin folds and between the transverse scrotal blood vessel minimizes bleeding and results in a virtually invisible scar. The tunica vaginalis is opened with electrocautery away from the epididymis and the testis, epididymis, and spermatocele are delivered.

In patients who are concerned with future fertility, an operating microscope providing 6× to 25× magnification should be used for the remainder of the dissection (30). Careful sharp and blunt dissection is recommended to excise the spermatocele. The cystic structure should be excised from the epididymis without excessive mobilization of the epididymis and testis themselves so as to decrease the risk of vascular injury to these structures. Dissection down to the efferent ductule that the spermatocele arises from is performed under the microscope with a combination of gentle sharp and blunt dissection, taking great care to avoid entering the spermatocele before dissection is completed; they should be ligated using 5-0 or 6-0 absorbable sutures and the spermatocele removed intact (Fig. 73.9). Sampling of the fluid from the spermatocele and examination of the fluid under a 400 power provided by a bench microscope confirms the presence of sperm and diagnosis of spermatocele. If the patient does not have any interest in future fertility and the spermatocele is densely adherent to the surrounding structures resulting in a difficult dissection, partial or total epididymectomy may be considered as a treatment option (18). After the spermatocele is excised and hemostasis assured, the testis is reduced into the tunica vaginalis and the tunical edges are reapproximated in a running fashion using absorbable suture. The testis is then returned to the scrotum in its proper anatomic orientation and hemostasis of the surgical field is obtained. The rest of the wound closure is performed as described for hydrocelectomy.

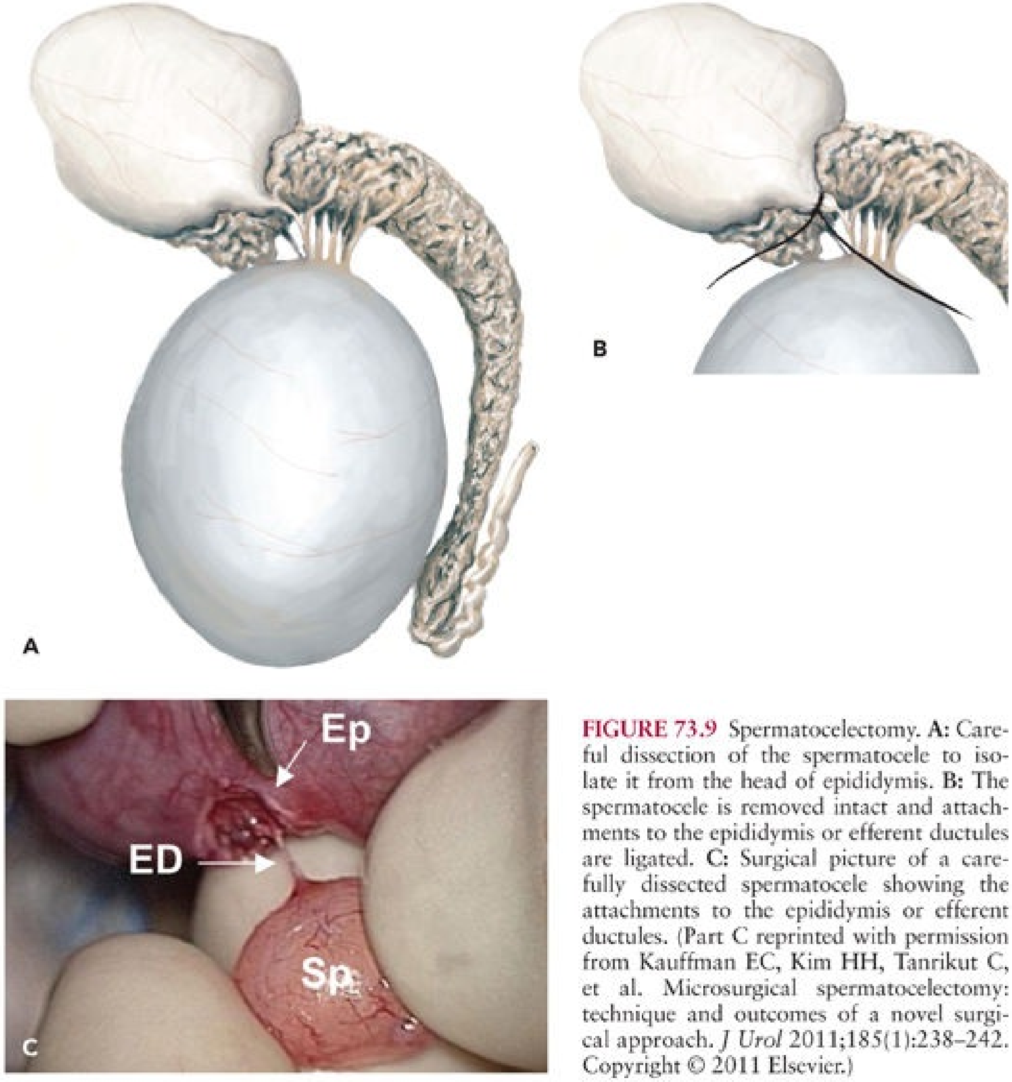

FIGURE 73.9 Spermatocelectomy. **A:** Careful dissection of the spermatocele to isolate it from the head of epididymis. **B:** The spermatocele is removed intact and attachments to the epididymis or efferent ductules are ligated. **C:** Surgical picture of a carefully dissected spermatocele showing the attachments to the epididymis or efferent ductules. (Part C reprinted with permission from Kauffman EC, Kim HH, Tanrikut C, et al. Microsurgical spermatocelectomy: technique and outcomes of a novel surgical approach. *J Urol* 2011;185(1):238–242. Copyright © 2011 Elsevier.)

Outcomes and Complications

Of primary concern is epididymal injury leading to obstruction and compromised fertility. The incidence of epididymal injury during spermatocelectomy is 17% (26), and there is evidence of permanent postoperative changes on semen analyses in most patients who undergo spermatocelectomy (31). Prior studies report recurrence rates after spermatocelectomy of 5% to 10% (25). The use of the operating microscope to enhance visualization of the epididymis and efferent ductules reduces the incidence of iatrogenic epididymal obstruction with no change in postoperative sperm counts and a possible decrease in recurrence rates when performed by a skilled microsurgeon (30). Additional complications that are typical of other scrotal surgeries can be seen including hematoma, hydrocele, infection, and testicular atrophy due to vascular injury.

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CHAPTER 74 CONGENITAL CURVATURE

ERIK GROSSGOLD AND JEREMY TONKIN

Patients with straight erections have normal and symmetrical expansion of all tissue layers of the penis. This requires normal tissue elasticity and compliance. During tumescence, the penis fills with blood and the tissues reach their limits of compliance. The limits of compliance of the tunica albuginea are especially important in rigidity; however, those with curvature may have an asymmetrical expansion of any one aspect of their penis. Thus, curvature can be due to decreased compliance of one aspect of the penis or foreshortening of one erectile body.

Penile curvature is described as either congenital or acquired. With regard to congenital curvature, there exists *congenital curvature* and *chordee without hypospadias*. Some use these terms interchangeably; however, they should not be thought of as synonymous.

Devine and Horton (1) proposed a classification system for congenital penile curvature consisting of five separate types of curvature. Types I to III can be collectively termed *chordee without hypospadias* (Fig. 74.1). This term in general refers to an abnormal development of ventral penile tissue in the presence of a normally placed meatus. For patients with type I, none of the surrounding layers are normal and there is malfusion of the corpus spongiosum. Patients with type II curvature have a dysgenic band of fibrous tissue lateral and dorsal to the urethra. This is believed to have formed from the mesenchyme that would have normally become the Buck and dartos fasciae. Type III congenital curvature exists in patients with a normally developed urethra, corpus spongiosum, and Buck fascia. The abnormality in these patients is in the dartos fascia, which has an elastic band that causes the penis to curve acutely. Not infrequently, these patients have a large and prominent mons pubis.

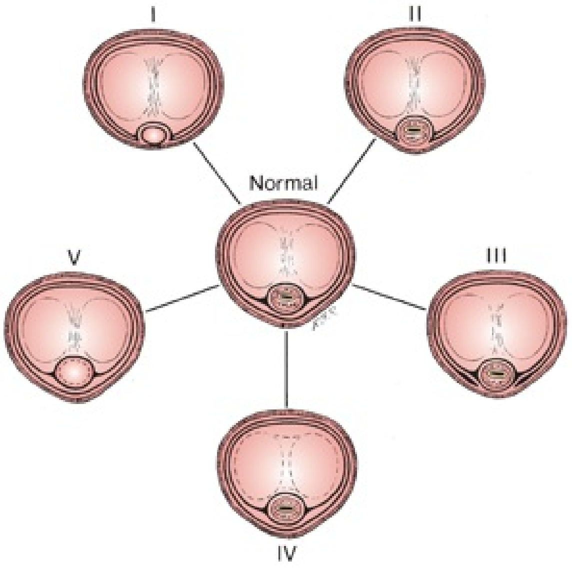

FIGURE 74.1 Cross section of the penis displaying the forms of congenital curvature of the penis. The normal penis is in the center. *Class I*: Epithelial urethra beneath the skin. Dysgenic tissue beneath it represents undeveloped corpus spongiosum, Buck fascia, and dartos fascia. *Class II*: Normal urethra and spongiosum but abnormal Buck and dartos fasciae. *Class III*: Abnormal dartos fascia only. *Class IV*: Normal urethra and fascial layers with abnormal corporocavernosal development. *Class V*: Congenital short urethra (rare). (Reprinted with permission from Devine CJ Jr, Horton CE. Bent penis. *Semin Urol* 1987;5:252. Copyright © 1987 Elsevier Inc.)

The authors refer to type IV curvature as congenital curvature of the penis. In type IV penile curvature, development of the urethra, fascial layers, and corpus spongiosum is normal. The defect is a relative shortness or inelastic area of the tunica albuginea. It is our experience that these patients have a penis of small or normal length when flaccid, but when erect, the penis may be larger than expected. This is thought to be due to hypercompliance of the tunica albuginea that allows hyperexpansion of the penis. Many of these patients will remember curvature prior to puberty, but this becomes more accentuated after pubescence and the penile growth spurt that occurs during adolescence.

Type V curvature is the rarest, and some have questioned whether it exists. This type is described as the congenitally short urethra. The short urethra is not elastic enough or of adequate length, leading to ventral curvature during erections.

DIAGNOSIS

Patients usually present in their late teens to early 30s. Most men cannot remember their penis ever being straight but may have assumed their curvature was normal. After puberty and the onset of sexual activity, they realize that their curvature impedes sexual relations. Some patients also attest that their curvature has worsened since puberty. Occasionally, a patient will present after the age of 30 years. This is due to either having been sexually active but found sex functionally or psychologically difficult or, less commonly, sexually inactive due to curvature and embarrassment issues.

All patients should undergo a complete history, including an extensive sexual history and physical examination. This should include time since onset and any prior traumatic events. Penile examination should focus on evidence of subclinical fracture or Peyronie disease, the latter being rare in this younger patient population. Patients at our institution are required to supply photographs of their erect penis for documentation of the curvature (Fig. 74.2). The photographs are also beneficial in distinguishing between congenital curvature and chordee without hypospadias. Psychological aspects of the disease also need to be addressed. On occasion, patients with significant psychological issues are evaluated preoperatively by a certified sex therapist and treated as needed.

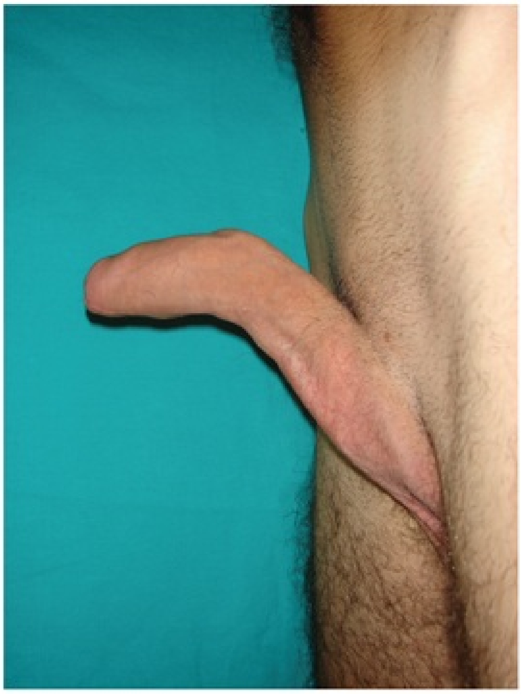

FIGURE 74.2 Preoperative photograph of an erect penis from a congenital curvature patient demonstrating a typical ventral curvature.

Patients with chordee without hypospadias usually present with a ventral or ventrolateral curvature (2) and usually have a penis that is normal or shorter than normal in length. As mentioned, these patients also recall penile curvature throughout their life but may note some progression of the curvature during or after puberty. Many of these patients have abnormalities of the ventral penile skin. This may be noted as a hooded prepuce or a high insertion of the penoscrotal skin (penoscrotal tethering). The deep ventral tissues of the penis may seem to be inelastic to examination and stretch. The inelastic tissue that is palpable is the dysgenic tissue that has replaced the Buck and dartos fasciae.

Some of these patients, because of their curvature and smaller-than-average length, have significant self-image issues. When identified, these are the patients who benefit from psychological counseling preoperatively.

INDICATIONS FOR SURGERY

Patients with congenital curvature usually have ventral or ventrolateral curvature. This can be poorly tolerated by the patient and/or their sexual partners. Patients who have significant enough curvature to impair their sexual function are candidates for surgery. Surgery for chordee without hypospadias is successful in this patient population, with most curvatures repaired in a single procedure. Many times, the curvature is corrected by excising the dysgenic tissue on the ventrum of the penis and mobilization of the corpus spongiosum. For patients with congenital curvature, many procedures have been described.

ALTERNATIVE THERAPY

There are no alternative therapies to surgery for this condition.

SURGICAL TECHNIQUE—CONGENITAL CURVATURE

There exists a wide variety of surgical procedures to repair congenital curvature, including incision and plication, incision with grafting, and penile disassembly. Most congenital curvatures are straightened completely with incision and plication alone.

Incision and Plication

In patients who have been previously circumcised, an incision is made through the circumcision scar. Due to the previous circumcision, the new patterns of lymphatic and venous drainage could lead to marked penile edema if an incision is made proximal or distal to the old scar. The incision is made down to the superficial layer of the Buck fascia. The penis is degloved in this plane. Once completely degloved, an artificial erection is created by introducing intravenous approved normal saline into the corporal space. Perineal pressure is needed initially to aid in storage, but prolonged pressure is not required because these patients have normal erectile function and will store the saline once initial tumescence is achieved. A tourniquet placed at the base of the penis is not recommended because this can mask or distort the proximal extent of curvature.

The artificial erection demonstrates the degree and location of maximal curvature. A layer of dysgenic tissue may be noted that includes the Buck and dartos fasciae. If so, this tissue is completely mobilized and excised. Care is taken not to injure the corpus spongiosum. In some cases, this will need to be detached from the glans to the penoscrotal junction. If injured, the urethra is closed primarily using a fine, absorbable suture. Patients who suffer from a differential elasticity between dorsal and ventral aspects of the corporal bodies may receive some benefit from the excision of the inelastic dysgenic tissue but are rarely straight and often require further maneuvers to straighten the penis. An artificial erection is repeated after this, and if straight, the skin is closed and the procedure is terminated (Fig. 74.3).

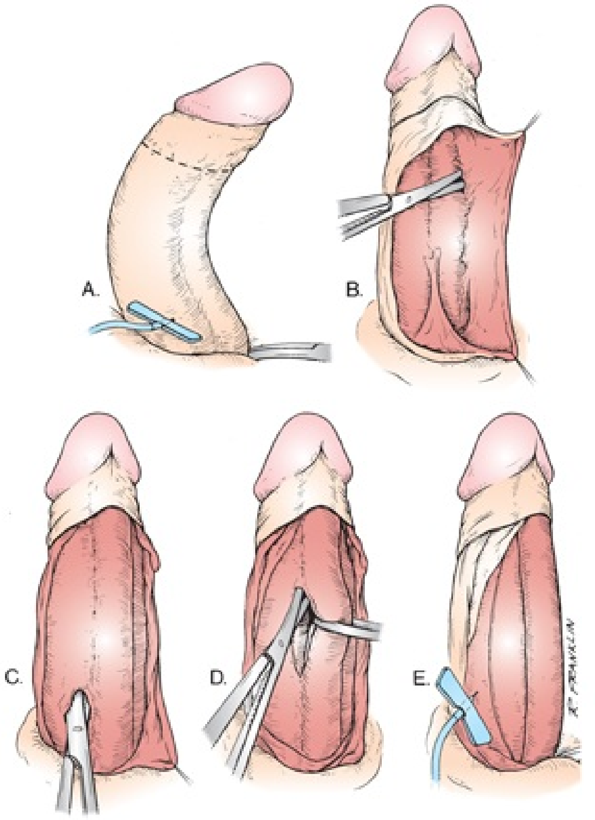

FIGURE 74.3 Surgery for chordee without hypospadias. A: Ventral curvature demonstrated with artificial erection. B: Dysgenic dartos fascia is elevated and will be excised. C: The dysgenic layer of the Buck fascia is undermined by spreading the scissors. D: The inelastic fascia is excised as the corpus spongiosum and urethra are mobilized. E: Artificial erection demonstrates correction of the curvature.

Further options to straighten the penis are to either lengthen the short side with incisions and grafts or to shorten the long side with excisions and/or incisions and plication. In many of these patients, penile length is not a major issue, and as such, we usually choose to excise and perform plications. The patients recover from plication procedures more quickly, and graft take is not an issue. Although rare, there is a possibility to induce veno-occlusive dysfunction with dermal grafts (Fig. 74.4).

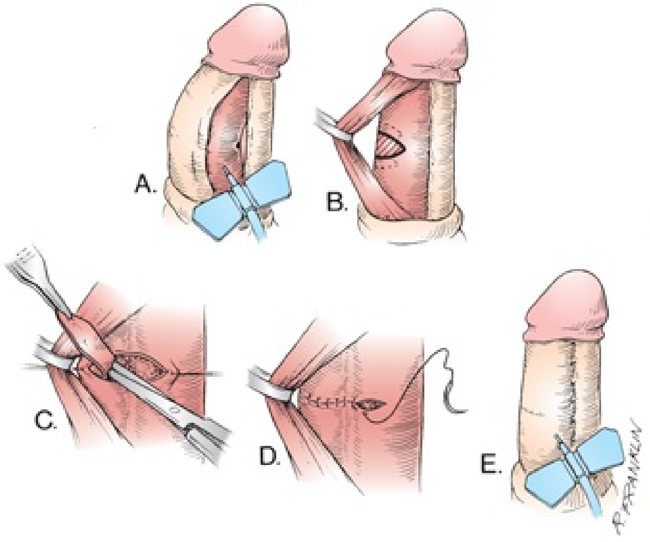

FIGURE 74.4 Surgery for chordee without hypospadias. A: A circumcision incision has been made and the urethra has been mobilized by resecting the dartos and Buck fasciae. The needle is in place for an artificial erection. The erection shows continuing chordee. The elastic urethra is not the cause of this curvature. The point of maximum concavity has been marked. B: An ellipse of tissue is outlined opposite the point of maximum concavity. As an alternative, two smaller ellipses are shown. C: Excision of the ellipse of tunica. Note the tips of the septal strands in the midline. D: Closure of the edges of the incision. E: Artificial erection revealing a straight penis. When the bend is more complex, ellipses must be excised in other locations. (Reprinted with permission from Devine CJ Jr, Horton CE. Bent penis. *Semin Urol* 1987;5:4. Copyright © 1987 Elsevier Inc.)

Once it has been determined to proceed with excision of tunica and dorsal plication, the Buck fascia is elevated, incorporating the neurovascular structures via one of two techniques. One approach is to start on the lateral aspect of the corpus spongiosum and carry the fascial elevation around to the dorsum of the penis. The alternative approach is to excise the deep dorsal vein and approach the tunica from the dorsal midline (Fig. 74.5). This approach requires excision of the dorsal vein and elevation of the inner layer of the Buck fascia off the tunica, including the dorsal neurovascular structures. This dissection is carried laterally and ventrally to the corpus spongiosum

(Fig. 74.6).

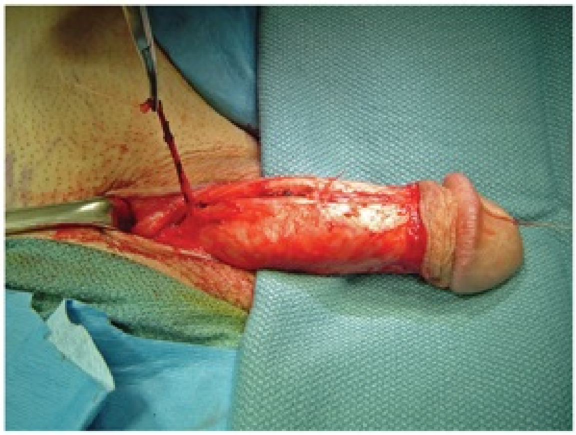

FIGURE 74.5 Dissection and ligation of the dorsal vein allows access to the plane between the tunica and the Buck fascia so that the dorsal neurovascular bundle may be mobilized.

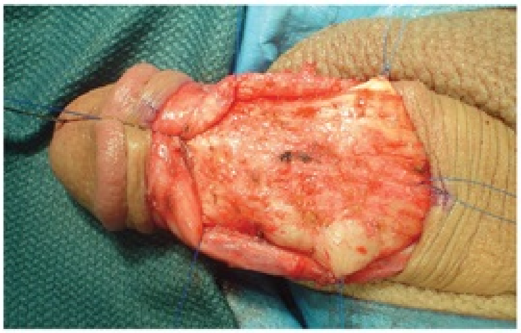

FIGURE 74.6 Dissection of the dorsal neurovascular bundles allows visualization of the tunica for straightening procedures. Stay sutures have been placed to elevate the tunica and retract the neurovascular bundles facilitating the excision and plication procedure.

After one of the earlier mentioned dissections is performed, an artificial erection is again performed and the point of maximal curvature identified. We mark this location with a suture that is later removed after penile straightening. The proposed areas of ellipse excision are identified and marked bilaterally. Matching excisions should be performed on each side unless lateral curvature is noted. In this case, excisions may need to be asymmetric. Edges of the planned ellipses are opposed with a 3-0 polypropylene (Prolene) suture or an Allis clamp, and a repeat artificial erection is performed. If this demonstrates adequate straightening, the edges are marked and the suture or clamp is removed. The ellipse of tunica is excised using a sharp no. 11 blade scalpel. The underlying erectile tissue is left undisturbed by staying in the space of Smith. Watertight closure is performed with interrupted 4-0 or 5-0 polydioxanone suture (PDS). An artificial erection is performed after each ellipse is excised and closed to determine results. If the penis is not straight, further ellipses are excised to straighten it. Many variations of the excision and plication procedure have been described. These include removing only the superficial layer of the tunica (3) or burying the tunical tissue instead of removing it (4).

Once straight, the Buck fascia is closed to prevent the dartos fascia from adhering to the tunica. Care should be taken not to entrap the dorsal neurovascular bundle with the closure sutures. Two small suction drains are placed. Usually, one drain is placed deep to and one superficial to the Buck fascia. The skin is reapproximated with a 4-0 Vicryl suture, and a small Foley catheter is placed overnight. A bio-occlusive dressing is placed. The Foley catheter is removed on postoperative day 1. One drain is removed in the morning as well, and if output is low, the other is removed that afternoon and the patient is discharged from the hospital.

Patients with lateral curvature usually have associated ventral curvature or rarely dorsal curvature. On occasion, patients with lateral curvature may have isolated lateral curvature, and in these patients, correction can be approached through a small incision at the maximal point of curvature. Preoperative pictures are extremely important in aiding detection of purely lateral curvature and when suspected an artificial erection prior to penile degloving will verify. After an artificial erection is obtained, the point of maximal curvature is identified and a small incision is made on the contralateral side of the maximal convexity. This allows for minimal dissection of the dorsal neurovascular structures. After 3-0 Prolene sutures or an Allis clamp are placed, an artificial erection is performed; if straight, ellipses are excised and closed as previously discussed (Fig. 74.7).

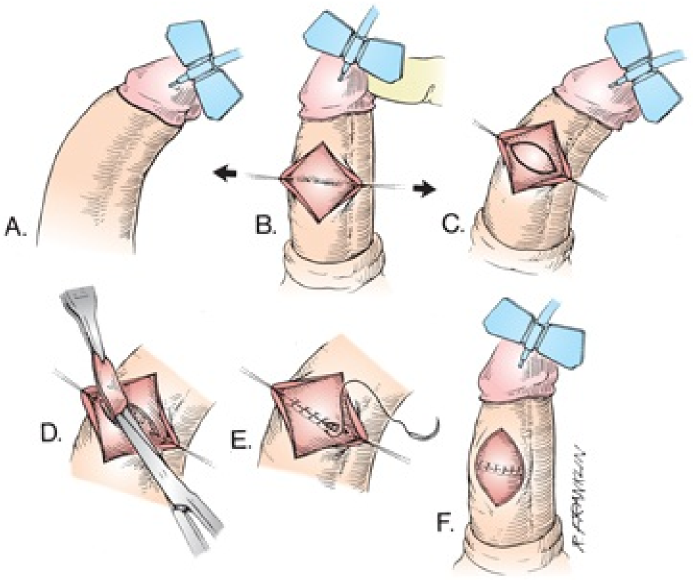

FIGURE 74.7 Congenital lateral curvature. A: An artificial erection reveals the curvature. The incision to gain access to the potential ellipse of tissue is marked. B: The tunica albuginea has been exposed by mobilizing the Buck fascia, and Prolene sutures have been placed at the dorsal and ventral tips of the potential ellipse. While maintaining the artificial erection, tension is established on the two sutures as the penile shaft is straightened. The fold produced in the tunica is marked. C: When the penis is relaxed, this mark defines the ellipse of tunica to be removed. D: The tunica is excised. E: The edges are approximated. F: The penis is straight. The Buck fascia and the skin are closed.

Although uncommon, congenital dorsal curvature is usually approached through a ventral midline incision. The corpus spongiosum is partially mobilized so that small incisions in the corpora can be placed just lateral to the ventral midline. The techniques used are those previously described, and the postoperative course is similar to that of the patient with ventral curve.

Although the use of absorbable and nonabsorbable suture has been described for penile straightening procedures, we prefer PDS as described earlier. This allows an absorbable suture that will also tolerate the pressure of any spontaneous postoperative erections. Although we routinely suppress postoperative erections using diazepam and amyl nitrate, this population usually has very good erectile function and spontaneous erections do occur. Avoidance of nonabsorbable suture may lessen the incidence of long-term palpable suture complaints (5).

Yachia Longitudinal Plication

Other techniques have been described for the repair of congenital curvature. Yachia (6,7) described a plication procedure using longitudinal incisions in the tunica albuginea that are closed transversely. This applies the Heineke-Mikulicz concept to penile curvature correction. The long side is therefore plicated without excising tunica. The procedure is similar to that previously described, with an incision through the previous circumcision scar and complete mobilization (Fig. 74.8).

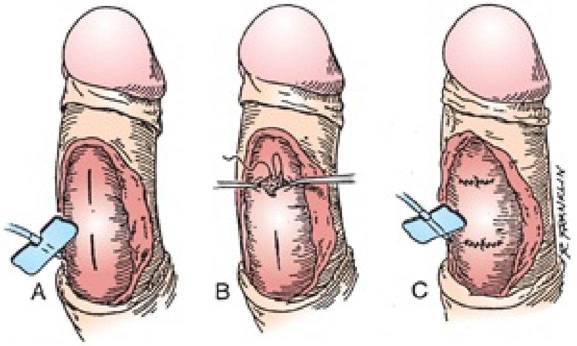

FIGURE 74.8 Technique after Yachia for correction of curvature, in this case, a patient with congenital lateral curvature. **A:** The Buck fascia is reflected, exposing the lateral tunica albuginea. **B:** Longitudinal incisions are created at the area of maximal curvature as demonstrated by artificial erection. **C:** The longitudinal closures are closed transversely, with artificial erection demonstrating good straightening of the penis.

Multiple Parallel Plication

Multiple parallel plication (MPP) is another technique described for the repair of congenital curvature of the penis without any tunical excision (8). In the original description, a pharmacologic agent is used to induce an erection. A circumcising incision is performed, the penis is degloved, and the dorsal vein and arteries are identified. The dorsal neurovascular bundle does not need to be dissected. Using four to six nonabsorbable 3-0 braided sutures, multiple deep plication sutures are placed into the tunica albuginea at the point of maximal curvature. These are placed between the deep dorsal artery and vein. Some of these sutures may not be fully tied down to prevent overcorrection. For patients with lateral or ventrolateral curvature, the sutures are placed more laterally using the same vertical orientation. When the patient has dorsal curvature, a midline ventral incision is made and the sutures are placed just lateral to the unmobilized corpus spongiosum.

Penile Disassembly

Perovic et al. (9) proposed a penile disassembly technique to avoid the penile shortening seen with the plication procedures. This technique requires complete disassembly of the penis into its component parts, these being the glans cap with its neurovascular bundle dorsally, the urethra ventrally, and the corporal bodies. Unfortunately, this technique only straightened the penis satisfactorily in 68% of patients, and on occasion, a plication procedure was still required.

Surgical Technique—Chordee without Hypospadias

The corpus spongiosum is rarely the limiting factor in these patients, even if they appear to have obvious abnormalities. The curvature in these patients is mainly due to the inelasticity of the ventral aspect of the corporal bodies. After the dysgenic tissue is excised, straightening is usually accomplished (10). After an artificial erection is obtained, any residual chordee can be corrected with a small incision in the ventral midline of the corporal bodies. The erectile tissue is not entered with this incision, and this allows the ventral tunica to move laterally, thus straightening the penis. If this is unsuccessful, the dorsal neurovascular structures are mobilized and a small ellipse of tunica is excised and closed as discussed earlier.

Some advocate the use of dermal grafts for patients with chordee without hypospadias, especially in those patients with severe chordee or those with a smaller-than-average penis. This approach avoids the shortening observed with the plication procedures but may increase the rate of complications. The major concern with placing a dermal graft is the risk of veno-occlusive dysfunction. Grafting the corpora cavernosa in any patient has the potential for creating erectile dysfunction and is a known complication when using dermis in adult patients with Peyronie disease. The majority of patients seeking surgery for congenital curvature are young adults, and the occurrence of erectile dysfunction can be devastating. It is thought that the pediatric patient may not develop veno-occlusive dysfunction because no tunica is excised and a much smaller graft is used than in the adult. No long-term studies have been published following these patients into adult life to determine the risk.

OUTCOMES

Complications

Surgical complications associated with congenital penile curvature surgery are relatively rare. This is in general a healthy population of patients. Some degree of penile ecchymosis is normal and is reduced by attention to hemostasis and the placement of suction drains. Complaints of penile shortening and penile irregularity from suture sites predominate. There are also complaints of suture granuloma and sometimes pain at the plication site. Temporary loss of glans sensation has been reported and can be expected due to traction on the neurovascular bundle. There is, however, one report of a patient with permanent loss of sensation. Postoperative erectile dysfunction is extremely rare because these patients usually have excellent preoperative erectile function. There is one reported case of penile necrosis secondary to a tourniquet which, as noted, we do not recommend using.

Results

The reported success rates of the Nesbitt, Yachia, and incision/ plication surgical procedures vary from 85% to 100% (11). Eight percent of MPP patients were satisfied with their correction, although two of the eight had to undergo a second procedure to correct a residual 15% curvature. All patients did notice the sutures, but only one considered them bothersome.

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CHAPTER 75 ILEAL CONDUIT URINARY DIVERSION

SAMUEL C. HAYWOOD AND ERIC A. KLEIN

Despite the established role of continent catheterizable and orthotopic voiding urinary diversion techniques, the ileal conduit remains the most common form of urinary diversion performed worldwide. The operation, first popularized by Bricker, maintains this popularity in large part because of its applicability to a wide variety of urologic disorders, its tolerability in patients with often significant comorbidities, and its adaptability to almost all patients' anatomic constraints.

DIAGNOSIS

The ileal conduit may be constructed as part of a reconstruction following extirpative pelvic surgery, such as radical or simple cystectomy and pelvic exenteration, or as a diversion with the bladder left in situ, such as in cases of neuropathic bladder refractory to conservative management. The clinical evaluation in these patients is therefore directed to their specific bladder pathology.

INDICATIONS FOR SURGERY

Before choosing an ileal conduit, patients should be counseled on all forms of diversion. Comorbidities such as renal insufficiency (serum creatinine >1.5 mg per dL or glomerular filtration rate <50 mL per minute), bowel disease (inflammatory or malignant), extreme obesity, or neurologic illness that prevents the ability to perform self-catheterization may make incontinent diversion a wise choice. Although it was suggested in the past that patients with cardiovascular/pulmonary disease or advanced age may do better with the shorter, simpler conduit diversions, newer evidence suggests that perioperative morbidity is equivalent with conduit and continent diversions (1,2).

ALTERNATIVE THERAPY

Continent catheterizable or orthotopic voiding diversions are the most common alternatives to conduit diversion. In addition, choices exist within incontinent diversion with respect to bowel segment (ileum, jejunum, stomach, and colon) and/or the type of ureteroenteric anastomosis (refluxing versus nonrefluxing). Conduits from nonileal bowel may be associated with higher metabolic complications but may be the only option in some patients. Further, the ability to accommodate nonrefluxing anastomosis in colonic conduits may protect kidney function and be preferable in children or adults with long life expectancy. Additional types of diversion are described elsewhere in the text. Patients undergoing concurrent pelvic exenteration are presented with additional options, including sigmoid conduits with transverse colostomy to avoid bowel anastomosis or the use of the double-barrel wet colostomy to drain both the fecal and urinary streams through a single tract.

Other potential urinary diversions include an ileovesicostomy, which can be used in benign disease to avoid complications associated with ureteral mobilization and anastomosis. Finally, patients with limited life expectancy may be considered for percutaneous nephrostomy tubes.

SURGICAL TECHNIQUE

Traditionally, surgical pathways for ileal conduit diversion have included preoperative bowel preparation. More recently, however, studies have shown that omission of this step may be done without adverse outcomes, including gastrointestinal or infectious complications (3,4). Broad-spectrum antibiotics are given at the time of surgery. The stoma site should be selected after examining the patient in the supine, seated, and standing positions. To best accommodate an appliance, the site should not be too near the anterior superior iliac spine, costal margin, umbilicus, surgical scars, or skin folds. The usual ideal location is just medial to the linea semilunaris, approximately one-third of the distance on a line between the umbilicus and the anterior superior iliac spine.

Markedly obese patients may require a higher site to allow them to perform stoma care under direct vision. In instances where there is a question regarding the ideal stoma site, ambulatory trials of pouching candidate sites or preoperative consultation with enterostomal therapy (where available) can help determine the optimal location.

The increasing prevalence of laparoscopy and robotics in pelvic surgery has led to the development of techniques using these for creation of the ileal conduit. Traditionally, creation of the urinary diversion had occurred extracorporeally after completing the laparoscopic portion of the case (as in radical cystectomy), but improvements in technique have allowed creation of urinary diversions completely intracorporeally. Initial reports of intracorporeal ileal conduit creation demonstrated this procedure to be both reasonable and safe (5). More mature data has compared the intracorporeal and extracorporeal diversions (both continent and incontinent) with respect to patient outcomes. The data showed similar operative times and reoperation rates and further suggested decreased complication rates among patients with intracorporeal diversions (6). Despite this, it should be noted that open approach to urinary diversion remains the standard of care given the surgical expertise required as well as lack of prospective data evaluating the minimally invasive approach and as such will be the procedure described in the following text. Further, associated procedures such as radical cystectomy require a minilaparotomy incision for specimen extraction limiting the benefits of completely intracorporeal diversion. Detailed techniques for intracorporeal creation of ileal conduit exist in the literature (7).

A low midline incision extending from just below the umbilicus down to the symphysis pubica allows for exposure of the bladder for cystectomy as well as bowel exposure for the conduit portion of the procedure. The patient is positioned supine. A Bookwalter-type retractor may be used to retract the bowel from the cystectomy field, and then the blades may be repositioned on the abdominal wall for the conduit procedure. The posterior peritoneum is incised at the pelvic inlet above the iliac vessels, where the ureter can be found coursing over the vessels. The ureters are then dissected with care distally and transected as close to the bladder as possible. A lesser degree of proximal mobilization is also usually necessary. During mobilization of the ureter, care should be taken to maintain its blood supply by leaving a generous amount of periureteral soft tissue. The distal ends of the ureters may be clipped to allow dilatation while the ileal conduit is harvested and prepared.

The terminal ileum is then identified and examined. If signs of inflammatory bowel disease, radiation changes, or insufficient mesenteric length are not present, then this segment is in general preferred for conduit formation. The mesentery is examined by transillumination, and the watershed area between the ileocolic artery and the right colic artery is selected for the distal mesenteric incision. This is typically located 20 to 25 cm proximal from the ileocecal valve, and the preservation of this length of terminal ileum suffices to maintain bile salt and vitamin B_{12} absorption. The bowel incision is continued proximally into the mesentery to allow the distal end to reach the stoma site without tension. Figure 75.1 demonstrates the isolation of the ileal segment.

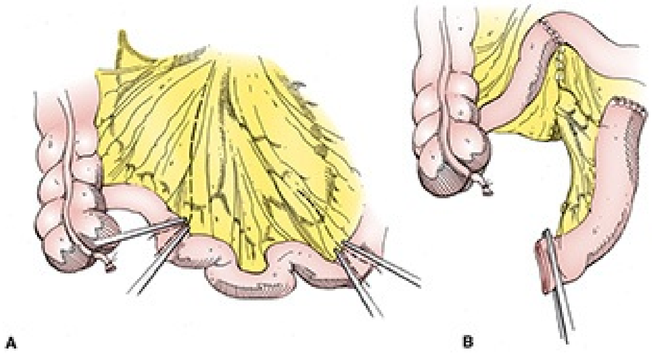

FIGURE 75.1 **A:** The ideal segment of bowel for the ileal conduit spares the terminal 10 to 20 cm of ileum and should require minimal ligation of mesenteric vessels to harvest. **B:** Once isolated, the conduit mesentery is positioned caudal to the bowel mesentery, which is reapproximated with a running silk suture.

The mesentery is again transilluminated, and a relatively avascular site is selected for the proximal incision. The optimal length of the conduit differs from patient to patient due to differences in body habitus and the degree of ureteral mobilization. The longest length of conduit should not exceed the distance between the sacral promontory and the stoma site; usually, if there is adequate left ureteral mobilization, a shorter length than this is optimal. If there is any question regarding the length, one should err on the longer side, as redundant conduit is much easier than insufficient conduit to treat intraoperatively. The conduit and its mesentery are positioned caudal to the rejoined bowel and its mesentery.

Standard hand-sewn or staple techniques are then performed to reestablish bowel continuity. The mesenteric window is also closed with a shallow running suture to prevent internal bowel herniation. Care should be taken during closure of the mesenteric window to avoid ligation of the ileal blood supply, which might compromise the healing of the anastomosis. Sterile towels are placed beneath the isolated ileal conduit, which is irrigated free of enteric contents with an antibiotic solution.

At this point in the procedure, either stoma formation or ureteroenteric anastomosis can be performed. This choice is based on surgeon preference. If ureteral stents are to be used, performing the ureteroileal anastomosis first allows for easier antegrade passage of the stent out of the distal end of the conduit. Creating the stoma first provides for more optimal localization of the ureteroileal anastomotic sites and helps direct the optimal level of the sigmoid mesentery through which the left ureter should be passed.

Construction of the stoma begins with the excision of a circular plug of skin around the preselected stoma site. Dissection is carried down to the anterior rectus sheath, and a cruciate incision is made in this layer. The posterior rectus sheath and rectus muscle are bluntly dissected after taking care to avoid the epigastric vessels. This dissection may be accomplished with a Kelly clamp, which then may be spread to create a hiatus for the conduit to pass through the abdominal wall. Traditionally, creating a hiatus approximately two fingerbreadths wide has been considered ideal to prevent compromise of mesenteric blood flow to the stoma. However, the rate of parastomal hernias in this population has been high, especially in obese patients (8). Ultimately, the size of the hiatus should depend intraoperatively on the width of the conduit. Creating a narrow passage will increase the risk of stomal stenosis, stomal retraction, or compromise of the blood supply. Conversely, a wide hiatus will predispose toward hernia and prolapse (9). To decrease the risk of parastomal hernia, the posterior rectus sheath is fixed with four separate sutures to the ileal conduit in order to prevent a sliding hernia.

In the standard end stoma (“rosebud”) technique, the efferent end of the conduit is grasped and pulled through the abdominal wall defect until the end is 2 to 3 cm above the skin surface. Each of the four tabs of the cruciate incision is then sutured to the bowel serosa, taking care not to pass sutures through the bowel mesentery. Absorbable sutures are then passed through the mucosal edge of the bowel, then the bowel serosa and muscularis deep to the skin edge, and finally through the dermal tissue just deep to the skin edge. Care is taken not to suture the bowel mucosa to the epidermis, as this can lead to mucosal rests that complicate pouching of the stoma. Figure 75.2 shows the technique of suture placement for the end stoma. Four quadrant sutures placed in this manner usually suffice to evert the stoma; additional sutures may be placed for reinforcement.

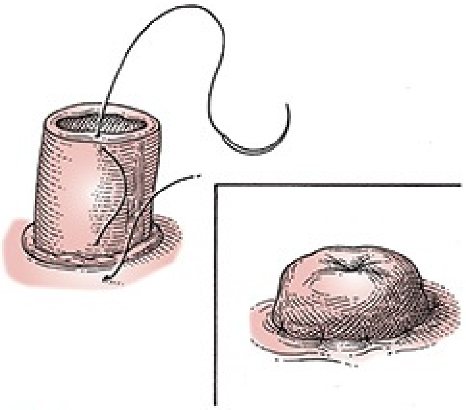

FIGURE 75.2 The end stoma (“rosebud”) is everted by passing sutures first through a full-thickness bite at the cut edge, then through the bowel serosa at the skin level, and finally through the dermis.

In obese patients or patients with a short mesentery, a Turnbull loop stoma should be considered. The distal end of the loop is closed with absorbable sutures (if the GIA stapler was used to harvest bowel, no additional closure is needed). An umbilical tape is passed through the mesentery at its border, with the ileum about 3 cm proximal to the end of the conduit. The tape is then grasped and pulled through the abdominal wall defect. A stomal rod is in general passed through the umbilical tape defect to prevent stomal retraction; this is then sutured in place and left in for 1 to 2 weeks. The blind end of the loop is positioned cephalad, and the loop is opened transversely nearer to the distal limb. The stoma is then matured using eversion sutures in the same manner described for the rosebud stoma. The technique for end-loop stoma formation is detailed in Figure 75.3.

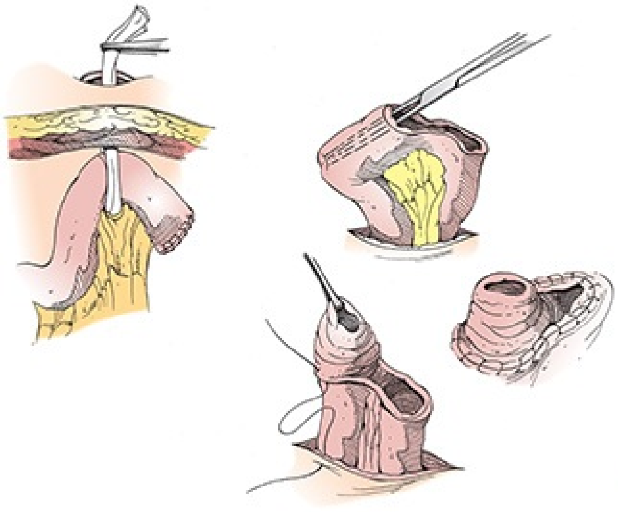

FIGURE 75.3 Creation of the end-loop stoma. The defunctionalized limb is positioned cephalad.

A long-term follow-up study comparing the results of loop versus end stoma revealed no major differences in outcome. Patients with an end stoma had slightly more ischemic complications, while those with the loop stoma required more frequent repair of parastomal hernias, presumably due to the need for a wider aperture in the abdominal wall (10).

Principles to consider in the creation of the ureteroenteric anastomoses include the maintenance of an adequate distal ureteral blood supply, the avoidance of tension on the anastomosis, the documentation of malignancy-free status in the distal ureter (if the diversion is performed for cancer), and the avoidance of ureteral kinking. Although more common with colonic anastomosis, nonrefluxing ureteroileal anastomoses have been described in the literature (11). The benefits of a nonrefluxing system have not been definitively shown, and the higher rate of anastomotic stricture and inability to use the loopogram study to evaluate the upper tracts limits the usefulness of this approach. Therefore, the freely refluxing end-to-side (Bricker) and conjoined end-to-end (Wallace) techniques remain the most commonly performed and recommended techniques.

In the Bricker technique, the proximal end of the conduit is either left closed if staples were used in the bowel harvest or closed in two layers with absorbable sutures. The left ureter is passed through a hole created in the sigmoid mesocolon. This hole is typically created at the level of the sacral promontory but may be moved cephalad or caudally to avoid ureteral kinking. A site on the conduit where the ureter lies naturally is incised down to the submucosal layer. The submucosa is grasped with forceps, and a small portion is excised along with its mucosa. The ureter is then spatulated, and a single-layer full-thickness anastomosis is performed with 4-0 or 5-0 interrupted absorbable sutures. Prior to closing the anastomosis, silicone ureteral stents may be placed; these can be guided in through the stoma using a Kelly clamp or a suction tip. Anchoring sutures through the ureteral adventitia and the bowel serosa may be placed 1 to 2 cm proximal to the anastomosis. Figure 75.4 demonstrates the ideal locations of the ureteroenteric anastomoses using the Bricker technique.

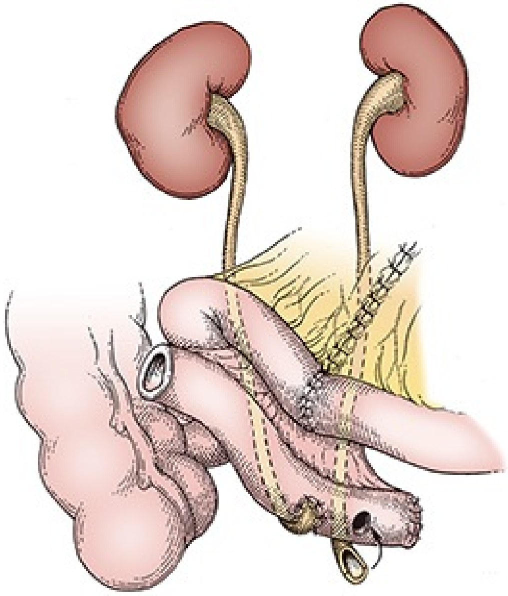

FIGURE 75.4 Ideal placement of the vesicoenteric anastomoses using the Bricker technique. The spatulated ureters should pass under the conduit and lie without tension or kinking.

The Wallace technique involves leaving the proximal end of the conduit open. The ureters are spatulated for a distance slightly greater than the conduit diameter. The posterior edges may be joined side-by-side or end-to-end using two running 4-0 absorbable sutures. One suture is then used to join the back walls of the conjoined ureters and the conduit, after which the anterior walls are closed. The side-to-side Wallace technique is detailed in Figure 75.5. Stents may be passed prior to closure of the anterior wall. This technique allows for the rapid creation of a widely patent ureteroileal anastomosis. However, disadvantages of this technique are that a process creating obstruction of one ureter (recurrent malignancy, anastomotic stricture) is more likely to cause bilateral obstruction and that retrograde investigations may be more difficult secondary to the right angle insertion of the ureters to the conduit. Further, a procedure to treat recurrent malignancy such as a nephroureterectomy requires additional anastomosis of the contralateral ureter.

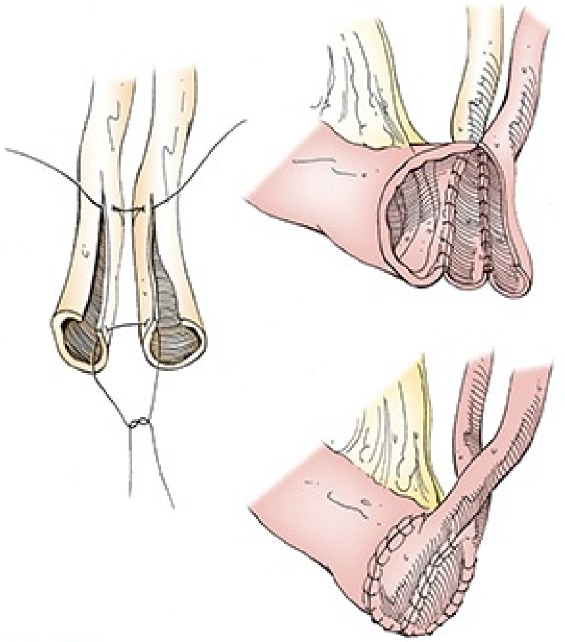

FIGURE 75.5 The side-to-side Wallace technique creates a widely patent vesicoenteric anastomosis at the "butt" end of the conduit.

After performing the ureteroileal anastomosis, the proximal end of the conduit is retroperitonealized by sewing the cut edges of the peritoneum to the conduit. Closed-suction drains (Jackson-Pratt type) are placed in the area of the ureteroileal anastomoses and maintained for the first few postoperative days.

The return of bowel function is the major determinant of the length of the postoperative hospital stay; this is evidenced by similar lengths of hospitalization for urinary diversion procedures with and without cystectomy. Most patients can expect a hospital stay of 4 to 7 days in centers with well-defined clinical pathways (12). Nasogastric decompression is optional. Some surgeons routinely use decompression for all postoperative patients, although more recent data suggests that early removal (13) or completely omitting nasogastric tube (14) may not prolong bowel recovery. The conduit also experiences an ileus, and its return of peristalsis parallels that of the small bowel; therefore, some surgeons advocate placement of a cut Foley or Rob-Nel catheter to promote conduit drainage in the first few postoperative days. There is no consensus regarding the need for ureteral stenting, although some reports suggest improved outcomes using stents (15). Timing of stent removal is left to the discretion of the surgeon, although it is recommended to remove them as early as possible after bowel function returns.

There is no consensus for the optimal length of ureteral stenting (if it is performed at all); the timing of stent removal is left to the discretion of the surgeon. Jackson-Pratt drains are left in place until the drainage is negligible; if drainage persists at high levels several days postoperatively, the drain fluid should be sent for creatinine analysis to rule out a urine leak. If a rod is left under the stoma, this may be removed prior to discharge.

Counseling and teaching by the enterostomal therapist should begin in the preoperative period and continue during the hospitalization. The patient or his or her caregivers should be competent in all aspects of stoma care prior to discharge. Ideally, the patient should be able to take care of the stoma personally to avoid undue dependency on caregivers. Follow-up care is tailored to the individual patient; in most cases, a periodic serum renal profile is indicated. The upper tracts can be assessed via a loopogram, avoiding the toxicity of intravenous contrast agents.

OUTCOMES

Complications

The mortality rates for cystectomy and diversion have steadily decreased since initial implementation. Nationwide, mortality averages approximately 2% (16), although in high-volume centers rates as low as 0.3% have been reported (17).

The most common morbidity causing prolonged hospital stay is ileus (17). This usually resolves quickly with nasogastric decompression; failure to do so after a few days should prompt a diagnostic workup for bowel obstruction. Urine leak at the ureteroileal anastomosis or from the conduit closure and urosepsis are the most common urologic complications of the procedure. Urine leaks can usually be managed successfully with placement of an abdominal drain and percutaneous nephrostomy diversion.

Late complications of ileal conduits are common but usually not severe. Stomal stenosis has been reported in 8% to 29% of ileal conduits (18,19); proper stoma construction can decrease this incidence. Flush stomas are more likely to shrink and become stenotic as compared to the rosebud technique. Definitive treatment includes removal or partial resection of conduit. Parastomal hernias have been reported in 14% of patients with obesity as an independent risk factor (8); stoma relocation may be superior to fascial repair in these cases. Hyperchloremic metabolic acidosis can occur but is rare in well-functioning conduit; the presence of more than a mild acidosis should prompt an evaluation for obstruction or redundancy of the conduit. Alkalinizing agents (sodium bicarbonate) or chloride transport blockers (chlorpromazine, nicotinic acid) can effectively treat this acidosis.

Ureteroileal anastomotic strictures are also uncommon (about 6% in older series); these can be successfully managed with endourologic balloon dilation or cold knife incision (about a 50% success rate), with open surgical repair (76% long-term success), or chronic ureteral stents (18). Notably, the use of minimally invasive techniques should be limited to short strictures; open repair should be used for longer strictures. Both the Wallace and Bricker style of anastomosis have acceptably low stricture rates; there has been some suggestion of lower stricture rate in the Wallace (20).

Acute pyelonephritis occurs commonly in patients with ileal conduits (18% of patients). Indeed, bacteriuria can be found in up to three-fourths of ileal conduit urine specimens (21). Most of these can be safely observed without treatment, as patients seem to tolerate this chronic colonization well, and few progress to acute pyelonephritis. Infections with *Proteus* or *Pseudomonas* are associated with deterioration of the upper tracts and should therefore be treated.

Deterioration in renal function occurs in a significant portion of patients undergoing conduit diversion; over the long term, 50% of patients have radiographic evidence of functional deterioration at 15-year follow-up, and up to 7% of patients can develop renal failure requiring dialysis (21). Renal function should be monitored periodically, and declines in function should alert the clinician to examine for correctable causes of renal dysfunction.

Results

The ileal conduit has provided reliable urinary diversion for patients with a variety of underlying illnesses for over 50 years. Continent catheterizable diversions and orthotopic neobladders continue to gain acceptance, and recent studies have focused on quality-of-life outcomes after continent and incontinent diversions. The existing evidence has not definitively shown superiority of continent diversion options over conduit diversion with respect to quality of life measures (22). Unfortunately, as younger, thinner, and healthier patients undergo continent diversion while older and more frail patients undergo ileal conduit, a real comparison of the quality of life after these procedures will likely never be possible. Still, it is clear that ileal conduit is a simple form of diversion that is well tolerated by most patients and has fewer contraindications than continent diversions. These factors make it likely that the ileal conduit will continue to play a major role in many urologists' practices.

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SECTION VII ■ URINARY DIVERSION

Section Editor: URS E. STUDER

CHAPTER 76 ■ TRANSVERSE COLONIC CONDUIT

MICHAEL RINK AND MARGIT FISCH

J. H. Nelson was the first to describe the high rate of early and late complications using irradiated small intestine for urinary diversion. Subsequently, he described the technique of the transverse colonic conduit in 1969 for the first time (1). Since the first publication, the transverse colonic conduit has been more used with increasing frequency in patients with urologic or gynecologic malignancy who have been treated with radiotherapy (2–7). The anatomic origin of the transverse colon in the upper abdomen close to kidneys and renal pelvises distinguishes this bowel segment from the small intestine or other colonic segments elucidating its obvious advantages for certain urinary diversion indications. With its cranial position outside of the pelvic irradiation field, it fulfills the demand to be nonirradiated, which is of utmost importance for a segment to be used for urinary diversion. Nonirradiated bowel segments offer less risk for postoperative urinary leaks and small bowel complications associated with bowel and ureteral anastomoses (3).

Not only the transverse segment but also the ascending and descending colon can be used, which offers an adaptation to the individual patient's situation. The long mesentery enables individual adaptation with positioning of the stoma either to the left or right upper abdomen. There are no limitations with regard to short ureters. The segment offers the feasibility for nonrefluxing as well as refluxing ureteral implantation (8–10). Colonic stomas usually are also less prone to stoma stenosis compared to the ileum.

In patients with total damage of the ureters by irradiation or retroperitoneal fibrosis and in patients with recurrent urothelial tumors (11), a direct anastomosis of the conduit to the renal pelvis represents an option (pyelotransverse pyelocutaneostomy) (12).

INDICATIONS

Indications for Surgery

The foremost indication for transverse colonic conduit is urinary diversion in patients with urologic/gynecologic malignancies and irradiation damage of bowel and distal ureters. Further indications comprise urinary incontinence in patients with radiation cystitis, complex vesicovaginal and rectovesicovaginal fistulae after irradiation, recurrent retroperitoneal fibrosis, Crohn disease, and unsuccessful primary urinary diversion requiring conversion. Complex cases of prostate cancer with a history of irradiation or brachytherapy and recurrent stenosis of the posterior urethra and/or fistula formation in addition to a small bladder capacity represent a rare indication. In patients with recurrent urothelial tumors of the ureters, a direct anastomosis of a conduit to the renal pelvises allows direct endoscopic access to the calices.

Contraindications for Surgery

Absolute contraindications for the transverse colonic conduit are irradiation of the upper abdomen, status post extensive colon resection, and ulcerative colitis. In addition, the use of colonic bowel segments should be considered carefully in patients with inflammatory large bowel disease and chronic diarrhea.

DIAGNOSIS

Preoperative Examinations

For upper urinary tract evaluation, an intravenous urography should be performed preoperatively. Nowadays, intravenous urography often is replaced by computerized tomography (CT) with urographic imaging. However, intravenous urography offers the advantage of being diagnostic and functional and may be considered in addition to CT.

Bowel imaging with water-soluble contrast media or colonoscopy should be performed preoperatively to exclude polyps or diverticula.

Patient Preparation

Nowadays, bowel preparation before urinary diversion is debatable, particularly in ileal diversions. For elective colorectal surgery, mechanical bowel preparation has been practiced as a clinical routine for many decades. However, contemporary randomized clinical trials and meta-analyses found no strong evidence supporting the use mechanical bowel preparation for elective colorectal surgery (13). Yet, the authors of this chapter recommend some type of bowel preparation prior to elective colonic surgery to reduce the stool burden. This may facilitate surgery and potentially avoid postoperative complications.

Finding the best localization of the stoma is an integral part of the preoperative preparation and of critical importance regarding avoidance of postoperative difficulties with stoma accessories, thus improving the patients' quality of life. Marking the site of the stoma should be done in cooperation between urologists and stoma therapists. To achieve best results, the stoma should be placed in an area free of scars or skin folds. The best position is in the epigastric region; the attached stoma plate has to be checked in sitting, lying, and standing positions of the patient. The patient should wear the stoma bag for several hours up to a day prior to surgery to figure out difficulties with the marked and designated location.

Intraoperatively, broad-spectrum antibiotics such as cephalosporins often in combination with metronidazole are usually given.

ALTERNATIVE THERAPY

A continent, cutaneous colon transverse pouch represents an alternative in young and healthy patients capable for catheterization (14).

SURGICAL TECHNIQUE

Instruments required include a basic kidney set with additional instruments for intra-abdominal surgery, an abdominal retractor, suction, and a basin containing prepared iodine solution for disinfection. As suture material, absorbable monofilament sutures such as polyglycolic acid 4-0 are used for closure of the conduit and intestinal anastomosis to reestablish bowel continuity as well as creation of the stoma. The ureters are implanted using 5-0 and 6-0 sutures. Intraoperatively, a gastric tube (alternatively gastrostomy) and a central venous catheter are placed.

Access is gained by median laparotomy. Both ureters are identified as they cross over the iliac vessels and dissected in the cranial direction. The dissection toward the bladder descends until the irradiated level is reached. The ureters are cut above the irradiated field where they show good vascularization. There should be capillary arterial bleeding from the ureteral wall and spontaneous urine efflux. The ureteral stump is ligated, and the cranial end is marked by a stay suture. Depending on the remaining length of the ureters, it is decided which one can be brought to the opposite side by a retromesenteric pull-through. The retromesenteric entrance should be wide enough, and the path of the ureter slightly curved in order not to angle or compress it.

A bowel segment of approximately 15 cm in length in patients with normal weight is selected respecting the course of the vessels (Fig. 76.1). The length of the segment depends on the thickness of abdominal wall. Stay sutures outline the segment. Bowel mobilization differs depending on the segment chosen: If the ascending segment is selected, the right colonic flexure is mobilized. The greater omentum is separated from the transverse colon over a distance of 10 to 15 cm starting at the right side. When the descending colon is chosen, the left colonic flexure has to be mobilized and the left part of the omentum has to be separated from the transverse colon. The selection of a transverse colonic segment makes mobilization of both the right and left flexure necessary as well as a complete separation of the greater omentum from the transverse colon.

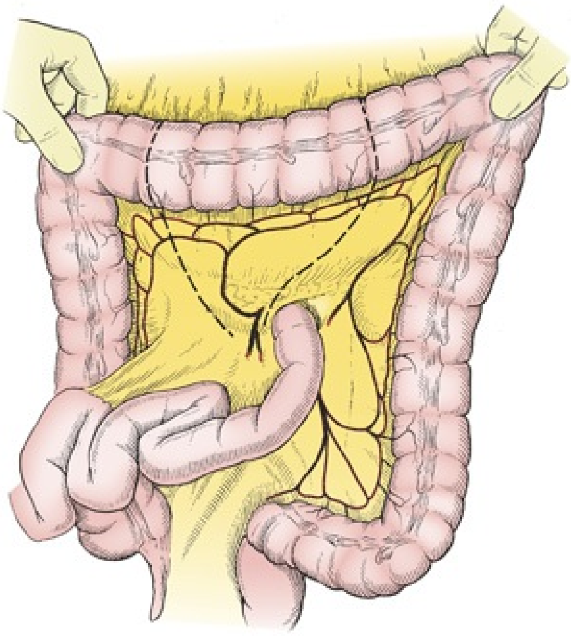

FIGURE 76.1 A bowel segment of approximately 15 cm in length in patients with normal weight is selected, respecting the course of the vessels.

The mesentery of the selected segment is incised lateral to the supplying artery, and the arcade is divided between mosquito clamps and ligated. The fat is dissected from the seromuscularis of the bowel in the area where the segment will be cut and bleeding vessels are coagulated. The segment is isolated without the use of clamps with the result that the bleeding out of the ends can be seen. The segment is cleaned using moist sponges. Bowel continuity is reestablished by a one-layer seromuscular suture using polyglycolic acid 4-0, and the mesenteric slit is closed by running suture

(Fig. 76.2).

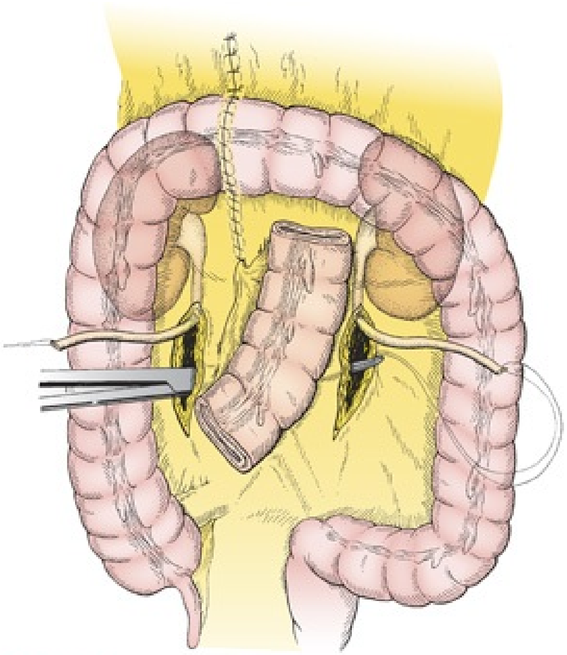

FIGURE 76.2 Bowel continuity is reestablished by a one-layer seromuscular suture using polyglycolic acid 4-0, and the mesenteric slit is closed by running suture.

One option for ureteral reimplantation is the refluxing Wallace technique (15). Both ureters are resected to an adequate length and spatulated over a distance of 3 cm. A stay suture is placed at the 6 o'clock position and a ureteral stent inserted. The first suture for anastomosis of the medial margins of the ureters is placed at the 12 o'clock position and tied later. The anastomosis is performed by a running suture with polyglycolic acid 5-0. The ureteral stents are fixed to the ureteral mucosa (polyglactin 4-0 with short reabsorption time) and subsequently brought out through the conduit. The ureteral plate is then anastomosed to the oral end of the conduit by two running sutures of polyglycolic acid 5-0 (Fig. 76.3A). When the conduit is positioned on the right side and the left ureter is relatively short, it can be implanted antidromic to the right ureter (like the "crossed hands of a ballerina"; Fig. 76.3B).

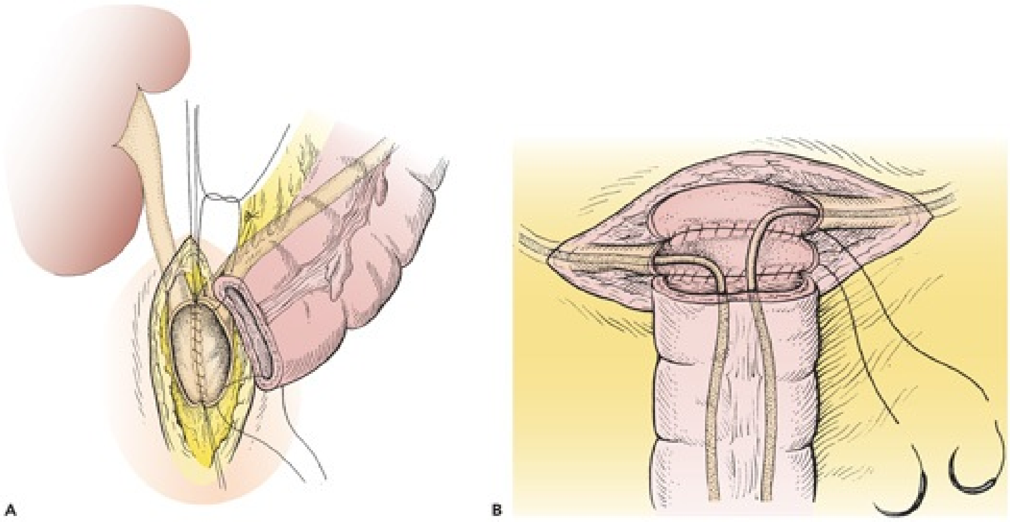

FIGURE 76.3 The ureteral plate is then anastomosed to the oral end of the conduit by two running sutures of polyglycolic acid 5-0. A: Classical implantation. B: Implantation with left ureter in opposite direction to the right.

An alternative method of refluxing ureteral reimplantation is a direct implantation using a "buttonhole" technique. The conduit is longitudinally opened in the area of the taenia libera over a length of 3 to 4 cm starting at the oral end. Two stay sutures are placed at the back wall of the conduit. The mucosa in between is excised and the seromuscular layer incised to create an entrance for the ureter. The ureter is pulled through and implanted by two anchor sutures at the 5 and 7 o'clock positions (polyglycolic acid 4-0) and mucomucous sutures (polyglycolic acid 5-0). A stent is inserted, fixed, and led out through the conduit (Fig. 76.4). The contralateral ureter is implanted in the same manner and the conduit closed.

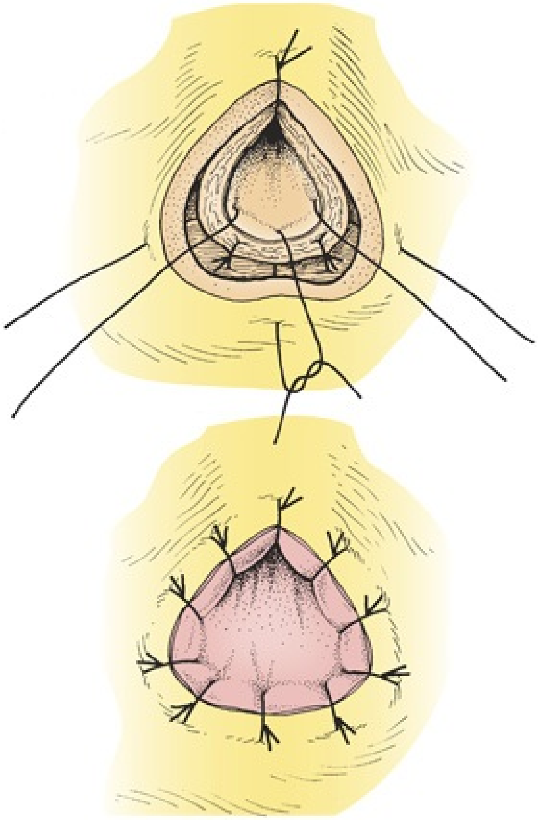

FIGURE 76.4 The mucosa in between is excised, and the seromuscular layer incised to create an entrance for the ureter.

An antirefluxive ureteral implantation can be performed using the Goodwin–Hohenfellner technique (16). The conduit is longitudinally opened over a length of approximately 4 cm starting from the end chosen for ureteral implantation (proximal end preferable). Four stay sutures are placed to facilitate ureteral implantation. A submucosal tunnel is dissected starting from the end of the conduit (tunnel length, 3 to 4 cm). The bowel mucosa at the end of the tunnel is incised, and the ureter is pulled through the respective submucosal tunnel. After spatulation and resection of the ureter to an adequate length, implantation is performed by one anchor suture at the 6 o'clock position, grasping the seromuscularis of the bowel and all layers of the ureter (polyglycolic acid 5-0). The anastomosis is completed by mucomucous single sutures (polyglycolic acid 6-0).

To secure the ureteral implantation, a 6Fr ureteral stent is inserted in each ureter and fixed to the bowel mucosa (polyglactin 4-0 with short reabsorption time). For implantation of the second ureter, a second tunnel is prepared beside and parallel to the first; the implantation is done in the same way (Fig. 76.5). Both ureteral stents are led out through the aboral end of the conduit. The proximal end of the conduit and of the incision line in the area of the taenia libera are closed (single seromuscular sutures, polyglycolic acid 4-0).

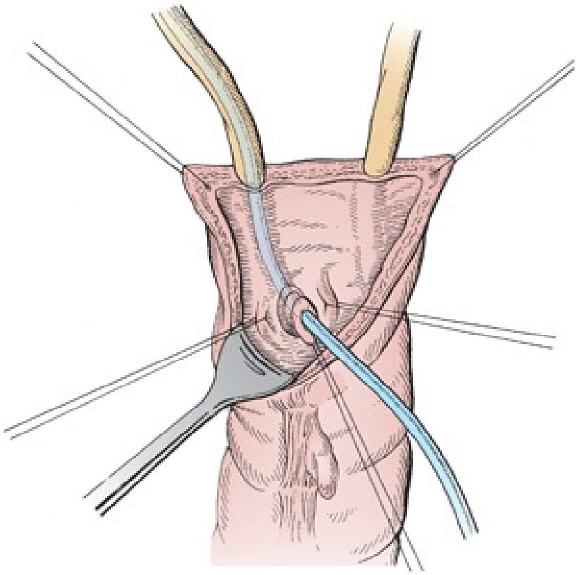

FIGURE 76.5 For implantation of the second ureter, a second tunnel is prepared beside and parallel to the first; the implantation is done in the same way.

A circular area of the skin (approximately 3 cm in diameter) is excised. The abdominal fascia is crosslike incised, and the conduit is pulled through the fascial and the skin opening, together with the ureteral stents, by means of two Allis clamps after having freed the distal end of the conduit of fat and epiploic appendages. The seromuscularis of the conduit is fixed to the abdominal fascia by circular single stitches of polyglycolic acid 3-0, and the conduit is anastomosed to the skin by circular single stitches of polyglycolic acid 5-0 everting the stoma (Fig. 76.6). An option may be passing the stoma through the rectus muscle in order to minimize the risk of parastomal hernia. However, stomal compression with compromised urine output may be a disadvantage.

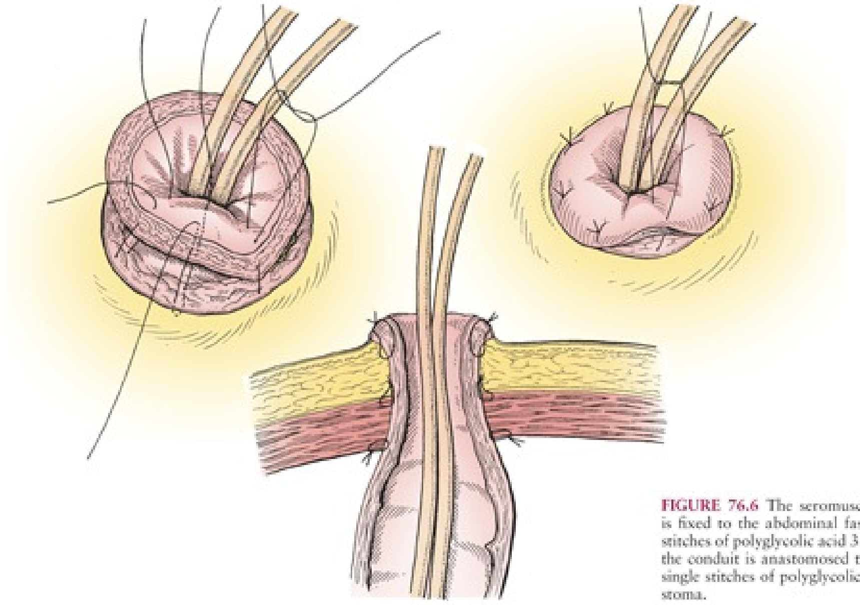

FIGURE 76.6 The seromuscularis of the conduit is fixed to the abdominal fascia by circular single stitches of polyglycolic acid 3-0, and the oral end of the conduit is anastomosed to the skin by circular single stitches of polyglycolic acid 5-0 everting the stoma.

Pyelotransverse Pyelocutaneostomy

An extensive bowel mobilization is necessary including cecum, root of the mesentery, Treitz ligament, and the right and left colonic flexures (Fig. 76.7A). The omentum majus is completely dissected from the transverse colon, and the bursa omentalis is opened. The bowel is exteriorized out of the abdomen. The ureters are cut at the ureteropelvic junction, and the renal pelvis is longitudinally spatulated. A transverse colon segment with a length of 25 to 30 cm and an adequate blood supply is isolated (Fig. 76.7B). After having placed a ureteral stent in a calyx of the right kidney and fixed the stent inside the renal pelvis (polyglactin 4-0 with short reabsorption time), an end-to-end anastomosis of the right renal pelvis and the distal end of the conduit is performed using two running sutures of polyglycolic acid 5-0. The ureteral stent is led out through the conduit before the anastomosis is completed. The conduit is brought to the left renal pelvis without tension (Fig. 76.7C). Likewise on this side, a stent is inserted into the kidney, fixed, and led out through the conduit later. For anastomosis of the renal pelvis with the conduit, the wall of the conduit is incised at the taenia libera over an adequate length and an end-to-side anastomosis of the renal pelvis and the conduit done by two running sutures of polyglycolic acid 5-0 (Fig. 76.7D). The stoma formation is identical to the standard technique. In patients with a single kidney, the technique is more simple: A direct anastomosis of the spatulated renal pelvis and the oral end of the isolated bowel segment is performed, and the aboral end led out through an abdominal stoma created as described earlier.

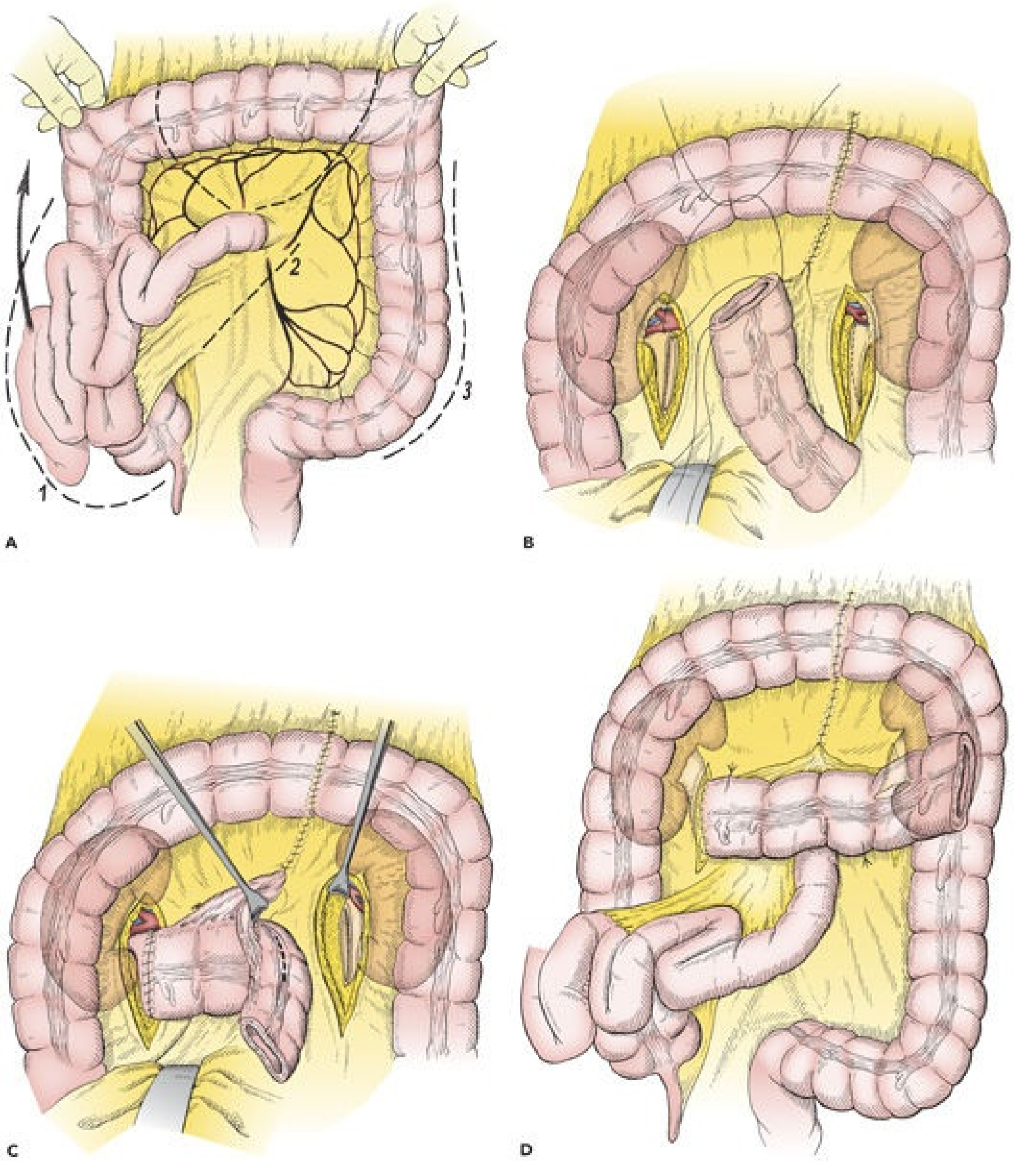

FIGURE 76.7 A–D: An extensive bowel mobilization is necessary including cecum, root of the mesentery, the Treitz ligament, and the right and left colonic flexures.

Surgical Tips

Transilluminating the mesentery by a fiberoptic light source visualizes the vessels and facilitates the selection of the segment as well as the preparation of the mesenteric slits. When the conduit is positioned on the right side and the left ureter is relatively short, it can be implanted directly to the right ureter (like the crossed hands of a ballerina). This is applicable for the Goodwin–Hohenfellner as well as the Wallace technique. The colonic conduit can be performed so that the urine flow is peristaltic and antiperistaltic so that the stoma can be alternatively positioned in the right or left upper abdominal quadrant. For an antiperistaltic application, an extensive mobilization of the Treitz ligament and the descending part of the duodenum becomes necessary; otherwise, compression of the duodenum by the conduit may result. If an isoperistaltic application is preferred, either the right or left colonic flexure can be used for conduit creation. An extraperitonealization of the conduit facilitates revisional surgery, and this can be done through a flank incision. Thereby, a transabdominal approach with the need for adhesiolysis can be avoided.

POSTOPERATIVE CARE

Antibiotics are given for 5 days. Originally as standard of postoperative care, parenteral nutrition was continued until bowel contractions appear and then gradually reduced. The gastric tube was removed starting from postoperative day 3 after clamping. The rectal tube stayed for 3 days. Nowadays, fast track regimens with early removal of the gastric tube and early oral nutrition are increasingly implemented. Ureteral stents are loosened after day 9 and removed after day 10, beginning on one side with a check of the kidney by ultrasonography on day 11. Then, the second stent is removed. An intravenous urography demonstrates regular kidney function after stent removal.

The acid-base balance should be checked before the patient is discharged. The patient should be taught about all aspects of stoma care.

OUTCOME

Results

Transverse colonic conduits offer reasonable short- and long-term results with low complication rates. The reported perioperative mortality rates range from 0% to 4%, with decreasing mortality rates in more contemporary series (5,6). The majority of patients show stable renal function in the early postoperative period (6). At a 10-year long-term follow-up, Schmidt et al. (7) found that upper urinary tracts and renal function remained stable or improved in 88% and 95% of patients, respectively; however, the study cohort was small. Transverse colonic conduit recipients who survived their underlying disease did well during long-term follow-up (7).

Complications

Contemporary data on peri- and postoperative complications are lacking. In older reports, immediate postoperative complication rates of 25% (17) and long-term complication rates of 13% to 37% (5,7,17) have been reported. Ureterocolonic insufficiency represents a specific early complication, whereas febrile urinary tract infection and ureter/implantation stenosis are common long-term complications (18). Electrolyte deterioration can be monitored by venous blood gas analysis. During long-term follow-up, approximately 10% of patients experience a temporary drop of the base excess under 2.5 mmol/L, but almost no patient with colonic conduit develops clinical acidosis or a decrease in blood pH and serum electrolyte disturbances. Nevertheless, some patients with colonic conduit receive prophylactic alkali substitution (19). Stoma stenoses are less prone compared to ileal conduit urinary diversion. Increased complication rates were observed in transverse colon conduit patients who were previously treated with very high dose pelvic irradiation (5). Therefore, a major goal of transverse colon conduit urinary diversion is the use of nonirradiated bowel and ureters for diversion.

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CHAPTER 77 ■ MANAGING THE PATIENT WITH ORTHOTOPIC BLADDER SUBSTITUTION

GIANLUCA GIANNARINI AND URS E. STUDER

Orthotopic bladder substitution has become the preferred method of urinary diversion, usually following radical cystectomy for malignant disease, in both male and female patients, provided that certain criteria are satisfied (1). The goal of this type of lower urinary tract reconstruction is to substitute the original bladder in both location and function by creating a reservoir that provides a safe and continent means to store and void urine through the urethra. This allows patients to preserve their body image, avoiding the need for a stoma and to recover an almost completely normal and socially integrated lifestyle.

Several types of bladder substitution have been developed over the past decades, each with its own specific advantages and disadvantages. However, regardless of the type of bladder substitute, optimal outcomes are achieved when a low-pressure, high-compliance reservoir is made of detubularized and cross-folded bowel segments with a preserved sphincter competence and no mechanical/obstructive outlet resistance. Good long-term results with any bladder substitute are not only dependent on surgical technique but equally importantly on a thorough preoperative assessment, meticulous active postoperative management, and lifelong patient follow-up.

PREOPERATIVE MANAGEMENT

Patient Selection

A thorough preoperative assessment requires that the following factors be evaluated when determining candidacy for orthotopic bladder substitution (Table 77.1).

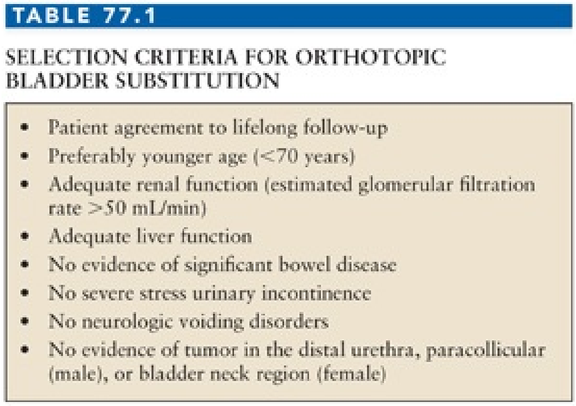


TABLE 77.1

SELECTION CRITERIA FOR ORTHOTOPIC BLADDER SUBSTITUTION

- Patient agreement to lifelong follow-up
- Preferably younger age (<70 years)
- Adequate renal function (estimated glomerular filtration rate >50 mL/min)
- Adequate liver function
- No evidence of significant bowel disease
- No severe stress urinary incontinence
- No neurologic voiding disorders
- No evidence of tumor in the distal urethra, paracollicular (male), or bladder neck region (female)

Patient Motivation and Mental Status

Perhaps the single most important factor contributing to a successful bladder substitute is patient motivation and willingness to comply with an indefinite follow-up. A thorough understanding of how one’s bladder substitute works is mandatory. Within this context, a dedicated specialized nurse can facilitate the preoperative assessment and postoperative education, as well as be a useful resource when patients have problems with their bladder substitute, by providing continuous and long-term educational reinforcement.

It is, however, the responsibility of the treating surgeon to thoroughly inform patients before surgery on all possible forms of urinary diversion and their relative benefits and risks should an orthotopic bladder substitution be not possible at the time of surgery. Alternative forms of urinary diversion to be discussed are continent cutaneous diversion, ureterosigmoidostomy, and incontinent cutaneous diversion (ileal conduit, ureterostomy, and percutaneous nephrostomy).

Patients should also be informed that the choice of a particular form of urinary diversion is primarily a quality-of-life decision with no or little impact on the course of the disease necessitating bladder substitution. Having this background in mind, patients are prepared to make a truly informed decision.

Adequate intellectual skills and physical dexterity, should intermittent self-catheterization become necessary, are currently relative criteria. Recent data has, in fact, shown that in men, the need to self-catheterize is rare, provided the reservoir has no outlet obstruction or this is promptly treated when it occurs (2). The problem remains for female patients in whom urinary retention may occur in up to 50% within 5 years postoperatively (1).

Age

Chronologic age should not be a criterion for offering orthotopic bladder substitution. However, in general, elderly patients (particularly octogenarians) have prolonged recovery of urinary continence and increased risk of long-term urinary incontinence (particularly nighttime) as compared to their younger counterparts (3,4).

Renal Function

The most frequent postoperative complications are metabolic acidosis and electrolyte abnormalities. The type and severity of these disorders depend on type and length of bowel segment used, time of urine contact with bowel mucosa, and compensatory renal reserve. An absolute contraindication to continent urinary diversion is a compromised renal function as a result of chronic renal failure or long-standing ureteral obstruction. Some patients with preexisting renal failure due to ureteral obstruction caused by their primary bladder cancer may recover sufficient renal function to allow for continent diversion once the obstruction is relieved. Placement of a percutaneous nephrostomy tube before surgery in these patients may provide a more accurate estimate of the true renal function. Currently, an estimated glomerular filtration rate of 50 mL/min is considered the lower limit so as to prevent the need for lifelong alkaline supplementation.

Liver Function

Adequate preoperative liver function is also mandatory. The continuous contact of urine with bladder substitute wall allows ammonium to shift through the bowel mucosa into circulation. A urinary tract infection caused by a urease-splitting organism will further increase this ammonium load. If baseline liver function is impaired, a hyperammonemia state will occur, which can lead to severe neurologic decompensation and eventual coma.

Bowel Function

Because bowel is needed for a bladder substitute, the impact of a prior bowel resection and diseased (e.g., Crohn disease) or irradiated bowel needs to be considered as it relates to malabsorption or diarrhea. The bowel segment used for the bladder substitute itself needs to be free of any pathology. Patients with compromised bowel function are better served by an ileal conduit.

Urinary Continence Status

Urinary incontinence, especially in female patients, may reflect a poorly functioning sphincter. These patients require preoperative urodynamic evaluation including a urethral pressure profile because this may identify an etiology and thereby potential treatment options. Severe stress urinary incontinence and neurologic voiding disorders are contraindications to an orthotopic bladder substitution.

Paracollicular and Bladder Neck Biopsy

Positive biopsies from the paracollicular region in the prostatic urethra or the bladder neck/proximal urethra in women indicate a high likelihood of a urethral recurrence. These patients should undergo a primary urethrectomy in conjunction with radical cystectomy and be considered for an alternative form of urinary diversion. Prostatic infiltration (superficial or stromal) proximal to the paracollicular region as well as carcinoma in situ and/or multifocal cancer of the bladder confer a higher risk of urethral recurrence but are not absolute contraindications for an orthotopic bladder substitution.

PREPARATION BEFORE SURGERY

The type of bowel preparation depends on the bowel segment used for the construction of the bladder substitute. If small bowel is used, a limited preparation with two enemas late in the afternoon before surgery is sufficient. Antegrade rinses and neomycin-erythromycin preparations are avoided. In addition, such preparations may increase the risk of fluid imbalances. In the elderly patient, this can produce cardiovascular instability due to intravascular volume depletion as well as potentially place the patient in a catabolic state prior to surgery. If large bowel is used, this must be freed from feces by antegrade irrigation or laxatives. A full mechanical bowel preparation is no longer required for colorectal surgery (5).

Subcutaneous deep venous thrombosis prophylaxis is started the evening before surgery and continued postoperatively. It is administered in the upper extremity so as to prevent a pelvic lymphocele. All patients receive perioperative antibiotic prophylaxis. Also, patients wear stockings and are taught appropriate exercises by a physiotherapist in order to prevent a deep venous thrombosis of the lower extremities or bronchopneumonia.

INTRAOPERATIVE MANAGEMENT

There are certain critical surgical steps that, if adhered to during radical cystectomy, will allow for optimal functional results of the bladder substitute.

Preservation of Pelvic Innervation

In general, nerve sparing should be performed on the non–tumor-bearing side and extensive resection on the tumor-bearing side of the bladder (Fig. 77.1). It has been shown that attempted nerve sparing during radical cystectomy in bladder substitute patients does not only increase the chance to maintain erectile function but also have a positive impact on daytime and nighttime urinary continence (3).

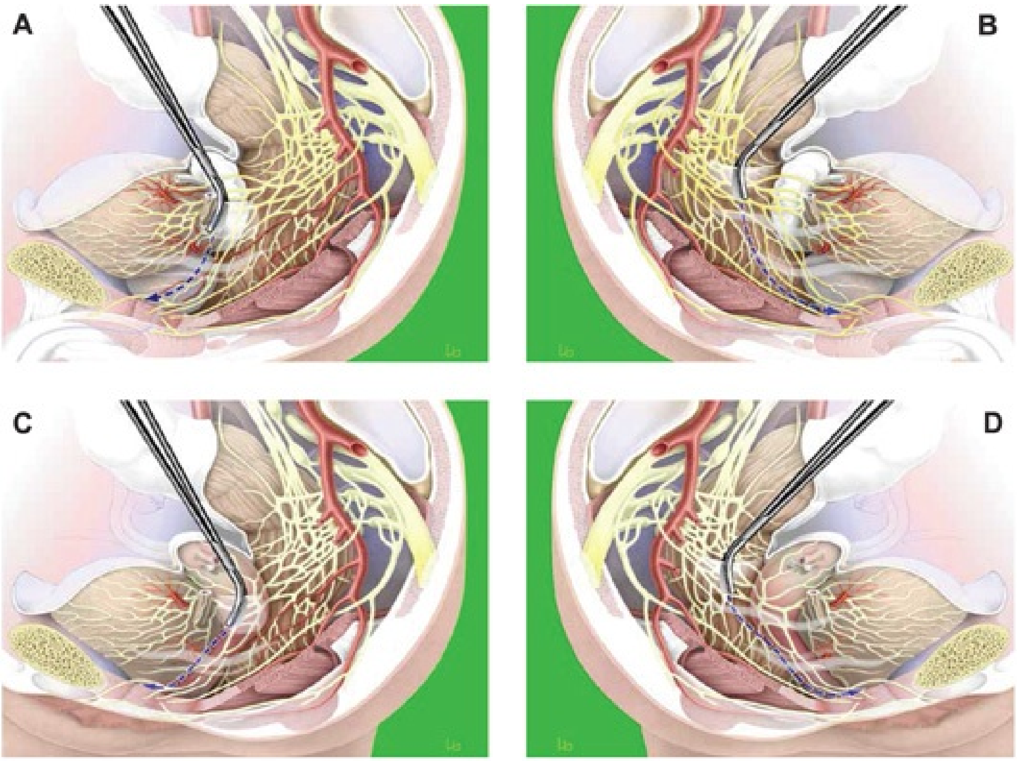


FIGURE 77.1 Dissection line for nerve sparing on the non–tumor-bearing side and for extensive resection on the tumor-bearing side of the bladder in male (**A and B**) and female (**C and D**) patients.

For nerve-sparing cystectomy in men, the nerve fibers in the dorsomedial pedicles lateral to the seminal vesicles as well as the periprostatic neurovascular bundle have to be spared. The pelvic plexus can be preserved by sectioning the dorsomedial pedicle along its ventral aspect, anterolateral to the seminal vesicles, and terminating the dissection at the base of the prostate. A nerve-sparing prostatectomy must also be performed which requires a lateral approach with incision of the endopelvic and periprostatic fascia and bunching of Santorini plexus at the level of the prostate and not distal to it. The dorsolateral neurovascular bundle can be separated from the prostatic capsule. The prostatic apex needs to be approached laterally directly along the prostatic capsule, and the membranous urethra is delivered sharply out of the donut-shaped prostatic apex to avoid nerve damage on the dorsolateral side of the urethra (6).

For nerve-sparing cystectomy in women, the vaginal wall dissection at the cervical level is in the anteroventral plane of the vagina, that is, at the 2 or 10 o'clock position. An empty sponge-holding forceps in the vagina helps facilitate dissection along the whitish vaginal wall. It is important to remain in close contact with the whitish wall of the vagina, thereby ensuring that the paravaginal venous plexus is hemostatically controlled and resected with the dorsomedial bladder pedicle. The endopelvic fascia is only incised cephalad to the bladder neck to minimize damage to the sphincter, its innervation, and to the intrapelvic branch of the pudendal nerve, which also contributes to urethral innervation (7).

Atraumatic Dissection of the Urethra

To obtain a maximum length of competent urethra, sharp and atraumatic dissection of the urethra with minimal use of electrocautery at the prostatic apex in men is used with preservation of the distal puboprostatic ligaments, which cover the membranous urethra. In female patients, the endopelvic fascia is not incised at its deepest point but along the bladder neck. This, together with the preservation of the pubourethral ligaments, will allow for urethral stability and improved urinary continence.

Ureters

Ureters need to be resected at a safe oncologic distance from the bladder, allowing for removal of periureteral lymphatics that may harbor micrometastases. In addition, by removing the distal ureter, the risk of ureteral ischemia and subsequent stricture formation is decreased. Furthermore, when mobilizing the ureters, the periureteral tissue must be preserved in order to ensure good blood supply to the anastomotic area, again in order to prevent anastomotic strictures. The left ureter is transposed without tension to the right side of the abdomen retroperitoneally by crossing the aorta above the inferior mesenteric artery. An antireflux ureterointestinal anastomosis (8) or other antireflux mechanisms (9) are not required in low-pressure bladder substitutes, rather they may be detrimental to the renal function. A long, spatulated, end-to-side anastomosis according to the refluxing Nesbit technique using a water tight running suture should, instead, be performed. Traction on the anastomosis can be avoided by placing interrupted sutures between the periureteral tissue and the bowel wall. Although stenting of the ureterointestinal anastomosis apparently does not lower the stricture rate, it may improve the recovery of bowel function and decrease the risk of metabolic disturbances in the early postoperative period (10). If ureteral stents are placed, they should be passed through the bowel wall where their exit sites are covered with mesenteric fat, so as to prevent urine leakage once they are removed.

Bladder Substitute

Several segments of bowel have been used over the past years for the construction of a bladder substitute. A comparison of the various segments has shown an advantage for ileum over any other segment (gastric, ileocolic, right colic, and sigmoid) with regard to capacity at first and at maximum contraction, involuntary contractions, elasticity, incidence of metabolic disorders, and long-term adaptation of mucosa from absorption to storage (11–13).

The most common segments currently used are ileum and colon. If ileum is used, the terminal ileum (i.e., the most distal 25 cm) needs to be preserved in order to minimize vitamin B12 deficiency and bile acid–induced diarrhea. The ileocecal valve should be preserved as well if possible or consideration should be given to its reconstruction (14). The ileocecal valve, in fact, controls the rate of delivery of ileal contents and prevents the migration of bacteria from colon into ileum. Ileal segments of up to 60 cm can be resected in healthy individuals without any significant consequences, provided the ileocecal valve is left intact. When more than 60 cm of bowel is resected, the risk of malabsorption increases and becomes inevitable if greater than 100 cm is used.

Resection of a considerable length of colon in isolation is possible without detrimental effect on absorption if the right colon remains intact. The right colon, in fact, retains solid residue for up to 8 hours determining the recovery of salt and water, whereas the left and rectosigmoid colon mainly function as a conduit. The right colon is particularly important in patients with ileal resection, in whom the severity of diarrhea increases as the length of any associated colonic resection increases (15,16). The severity of diarrhea depends more on length for contiguous colonic than ileal resection. Therefore, it may be best to avoid contiguous colonic and distal ileal resection in the formation of a continent urinary reservoir.

One hour prior to bladder substitute construction, administration of anesthetics via the epidural catheter is stopped. This prevents increased smooth muscle tone and activity of the ileum, which would, otherwise, result in a functional shortening of bowel with the risk of removing more bowel than is necessary for reservoir construction.

The reservoir should be spherical in order to achieve maximum capacity and minimal pressure for the given surface of bowel used. As dictated by Laplace law (pressure = tension/radius), intraluminal pressure is low for a given tension because conversion of a tubular structure into a spherical reservoir increases the radius. Furthermore, the spherical shape obtains maximal capacity, whereas the surface/volume ratio limits the reabsorbing surface and therefore minimizes associated metabolic disturbances.

It is mandatory that the anastomosis between the bladder substitute outlet and the urethra is not to the funnel-shaped end of the reservoir. This error would increase the risk of kinking and obstruction at the anastomotic site, especially when the reservoir is full. To obtain optimal voiding, the anastomosis should sit broadly on the pelvic floor (Fig. 77.2). In addition, all suture material should be absorbable, thereby eliminating any potential nidus for stone formation.

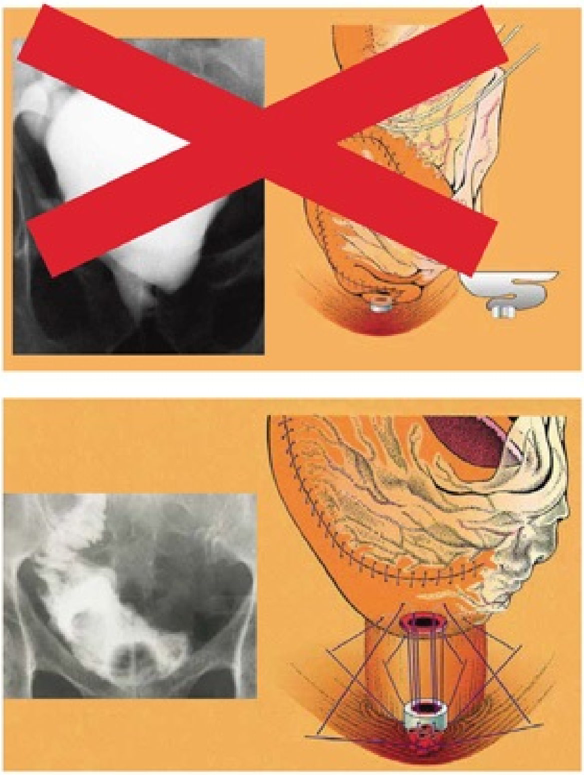


FIGURE 77.2 A funnel-shaped reservoir to urethra anastomosis must be avoided because of the risk of subsequent kinking and outlet obstruction.

POSTOPERATIVE MANAGEMENT

During the postoperative period, fluid and electrolyte management predominates; however, it is also important to use this time to educate and encourage patients to become comfortable with their bladder substitute (Table 77.2).

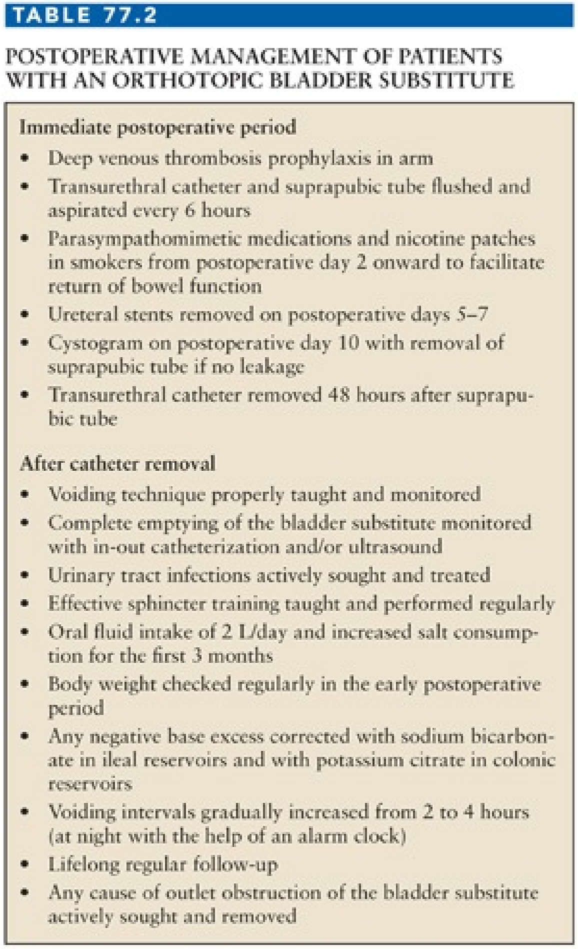


TABLE 77.2

POSTOPERATIVE MANAGEMENT OF PATIENTS WITH AN ORTHOTOPIC BLADDER SUBSTITUTE

Immediate postoperative period

- Deep venous thrombosis prophylaxis in arm
- Transurethral catheter and suprapubic tube flushed and aspirated every 6 hours
- Parasympathomimetic medications and nicotine patches in smokers from postoperative day 2 onward to facilitate return of bowel function
- Ureteral stents removed on postoperative days 5–7
- Cystogram on postoperative day 10 with removal of suprapubic tube if no leakage
- Transurethral catheter removed 48 hours after suprapubic tube

After catheter removal

- Voiding technique properly taught and monitored
- Complete emptying of the bladder substitute monitored with in-out catheterization and/or ultrasound
- Urinary tract infections actively sought and treated
- Effective sphincter training taught and performed regularly
- Oral fluid intake of 2 L/day and increased salt consumption for the first 3 months
- Body weight checked regularly in the early postoperative period
- Any negative base excess corrected with sodium bicarbonate in ileal reservoirs and with potassium citrate in colonic reservoirs
- Voiding intervals gradually increased from 2 to 4 hours (at night with the help of an alarm clock)
- Lifelong regular follow-up
- Any cause of outlet obstruction of the bladder substitute actively sought and removed

Immediate Postoperative Period

The suprapubic tube and transurethral catheter must be flushed and aspirated with saline 0.9% every 6 hours. This is needed to prevent mucus buildup, which can block catheters and result in rupture of the bladder substitute. This complication is greatest when bowel activity has resumed with the catheter still in situ. To prevent abdominal distension and accelerate return of bowel function, parasympathomimetic medications (e.g., neostigmine methylsulfate 0.5 mg three to six times a day subcutaneously) and nicotine patches (in smokers) are started 2 days after surgery. The ureteral stents should be removed between postoperative days 5 and 7 after the bowel function resumes.

On postoperative day 10, the suprapubic tube can be removed, provided a cystogram rules out urinary extravasation. The transurethral Foley catheter remains in place for an additional 2 days to provide enough time for the suprapubic tube exit site to heal.

Management after Catheter Removal

After all catheters and drains are removed, any bacteriuria should be managed with antibiotics until the urine is sterile. Infected urine can cause reservoir instability with subsequent urinary incontinence as well as increased mucus production, which can lead to increased postvoid urine residual and even urinary retention (17).

Voiding and Urinary Continence

Patients must be carefully instructed on how to void. Initially, they are taught to empty the bladder substitute every 2 hours during the daytime in a sitting position by relaxing the pelvic floor and, if necessary, by also slightly increasing their intra-abdominal pressure. At night, they should use an alarm clock to void every 3 hours. The adequacy of emptying needs to be monitored with in-out catheterization and/or ultrasound of the reservoir after voiding.

Patients without or after compensation of metabolic disturbances are instructed to retain urine thereafter for 3 hours and later for 4 hours in order to expand their bladder capacity. During this exercise, increased bladder substitute pressures may cause incontinence, but the elevated pressures are required to increase the reservoir's capacity. Therefore, patients are advised not to void when they experience such urinary leakage; otherwise, the bladder substitute will never achieve the desired capacity. It is essential to increase the capacity to approximately 500 mL in order to have low end-fill pressures to ensure urinary continence. With increasing capacity, nighttime continence will improve, but, on the other hand, a bladder substitute capacity of >500 mL should be prevented. Overdistension of the reservoir will result in a "floppy bag" unable to adequately empty with increased residual urine and the potential for urinary retention.

A postvoid urinary dribble incontinence can be prevented by instructing the patient to milk the urethra at the end of each void (18). Time required to achieve urinary continence depends on diligent sphincter training, patient age, as well as achieving intraoperative nerve preservation to the urethra and pelvic floor (if oncologically safe).

Urethral length, especially if the sphincter is damaged, is also important in the genesis of urinary incontinence as demonstrated by the formula: urinary continence = urethral length × closing urethral pressure (19). Using the female sheep model, Strasser et al. (20) showed that maximal urethral closure pressure was markedly decreased in sheep with denervated urethra (18 cm H_2O compared to baseline of 49 cm H_2O). If the autonomic nerves are damaged, closing urethral pressure cannot compensate for a shortened urethral length. Theoretically, therefore, after resection of the proximal urethra, patients may not leak with increased intra-abdominal pressure because of the intact pudendal nerve pathway but may leak when walking, particularly with a full bladder substitute, because of reduced functional urethral length or decreased closing pressure at rest. Also, sensory innervations of the proximal urethra may influence urinary continence. Division of these nerves may result in loss of the afferent limb of the external sphincter guarding reflex stimulated by urinary leakage into the proximal urethra. Nerve sparing may also be beneficial to preserving the function of the other pelvic organs. In a further experimental setting using a male canine model, Zehnder et al. (21) showed that not only smooth urethral sphincter function but also cavernosal body and smooth rectal sphincter function was preserved significantly better after a nerve sparing compared to a non–nerve-sparing cystoprostatectomy.

When adhering to all these principles, daytime continence rates of up to 90% and nighttime continence rates of up to 80% at 12 months can be achieved (4,22).

Urinary retention tends to be a problem primarily in female patients with bladder substitute. Having an unobstructed outlet with prevention of kinking of the urethra or reservoir can help avoid this eventuality (Fig. 77.2). The contribution of the intrapelvic pudendal somatic nerves and autonomic branches of the pelvic plexus to sphincter function has not been fully established, but animal studies have demonstrated a pressure increase in the distal urethra after pudendal nerve stimulation and in the proximal urethra after stimulation of the pelvic plexus. This suggests that nerve sparing has functional significance for both continence and voiding ability. In female sheep, Strasser et al. (20) found marked degeneration of the smooth muscle cells of the proximal urethra after bilateral denervation of an isolated urethra, which reflects the situation in bladder substitute patients. Thereby complete autonomic denervation of the urethra in patients undergoing cystectomy and bladder substitute may result in long-term smooth muscle dysfunction. Absence of the tonus-regulating function of the autonomic nerves may lead to a dilation or rigidity of the urethra resulting in intrinsic sphincter deficiency. A denervated proximal urethra may result in ineffective active relaxation and/or kinking during voiding and, thus, incomplete emptying which necessitates intermittent self-catheterization.

Metabolic Acidosis

After catheter removal, the patient is at an increased risk for metabolic acidosis. Both the urologist and the patient should be aware of the symptoms that may arise with a metabolic acidosis, such as lack of appetite, fatigue, weakness, weight loss, dyspepsia, heartburn, nausea, and ultimately vomiting. The base excess should be monitored with regular venous blood gas analysis, and a negative base excess needs to be corrected.

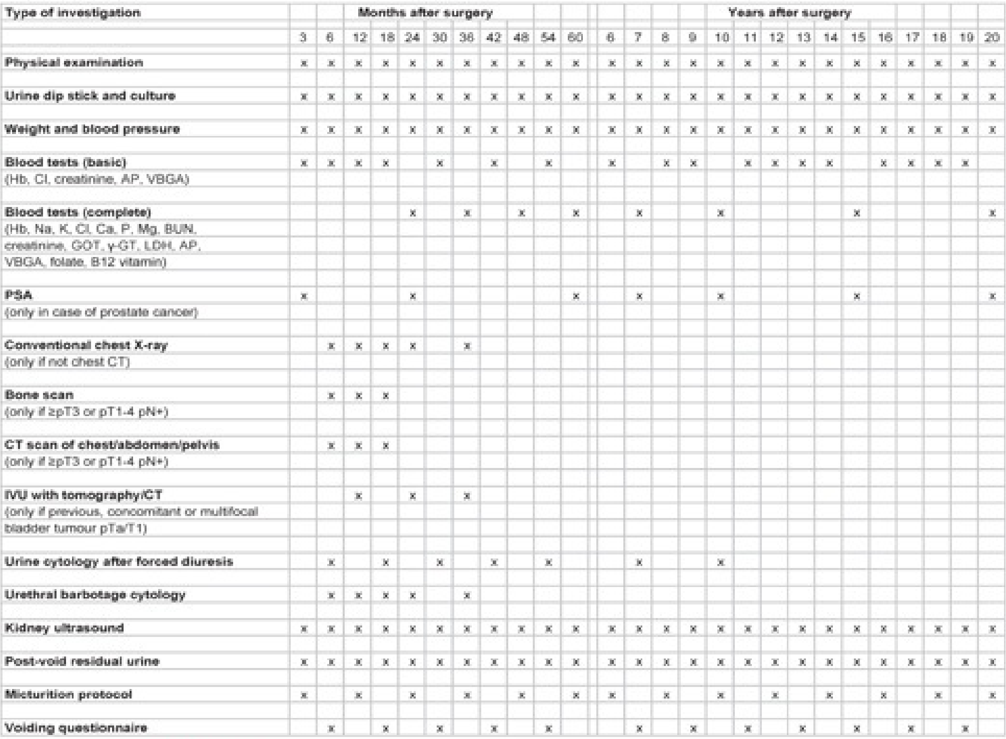
Because the main goal of any intestinal segment is to produce isosmotic contents, the bladder substitute has the ability to rapidly absorb or secrete sodium and chloride ions in response to the osmolarity of its contents (14):

1. If small bowel is used in the initial postoperative period, when the urine is hypo-osmolar, the bladder substitute will secrete sodium chloride resulting in a salt-losing syndrome, hypovolemia, and metabolic acidosis. The resultant dehydration and anorexia may lead to a rapid decrease in body weight and, therefore, daily postoperative body weight assessment is essential. To prevent this metabolic cascade, patients should increase their salt intake, primarily because they are also encouraged to consume 2 to 3 L of fluids a day to prevent metabolic acidosis resulting from highly concentrated acidotic urine. They also receive sodium bicarbonate supplementation (2 to 6 g) to maintain a positive base excess. With time, the villi will atrophy and this syndrome will become less pronounced.
2. Because the main absorptive function of large bowel is water recovery through active sodium and chloride reabsorption, its use for urinary reservoirs may lead to serum hyperosmolarity and subsequent decreased aldosterone release with increased antidiuretic hormone release. This metabolic disturbance results in highly concentrated urine from which the colonic mucosa will absorb more sodium and chloride. Typically, all these patients with close scrutiny have at least a mild degree of hyperchloremic metabolic acidosis. This can be treated with alkalizing agents and/or blockers of chloride transport. Hypokalemia and total body depletion of potassium may be more frequently seen with colonic diversion because ileal segments absorb more potassium. Therefore, treatment with potassium citrate is the most appropriate form of substitution for patients with large bowel reservoirs.

Comparative studies of ileal and colonic reservoirs are limited, as the absorptive surface areas are difficult to calculate. However, in the colon, chloride absorption and bicarbonate excretion are more pronounced, and there is evidence to suggest that inherent chloride absorption is maintained when in contact with urine. Metabolic acidosis is encountered in up to half of patients with an ileal bladder substitute soon after surgery, particularly in those with previous renal impairment or ongoing urinary infection, but most patients do not require sodium bicarbonate supplementation for >3 months (22). Conversely, up to more than one-third of patients with ileocecal bladder substitute require a lifelong substitution with potassium citrate (23). Therefore, it may be preferable to use ileum rather than colon for bladder reconstruction to reduce the risk of hyperchloremic acidosis, particularly in the presence of preoperative renal impairment.

Long-Term Follow-up

Meticulous and lifelong follow-up is essential for optimal reservoir function and prevention of long-term complications (22,24,25). The ideal bladder substitute should have no incontinence, no relevant postvoid residual urine, no urinary infection, no impairment of renal function, and no metabolic disturbances (e.g., acidosis, vitamin B_{12} deficiency, osteopenia). These points, together with screening for metastases, upper tract, or urethral recurrence, should be routine because without a regular follow-up, serious, if not life-threatening, complications, such as urosepsis, are likely to occur. A suggested protocol is illustrated in Figure 77.3.



Type of investigation	Months after surgery											Years after surgery														
	3	6	12	18	24	30	36	42	48	54	60	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Physical examination	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Urine dip stick and culture	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Weight and blood pressure	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Blood tests (basic) (Hb, Cl, creatinine, AP, VBGA)	x	x	x	x		x		x		x		x		x	x		x	x	x	x		x	x	x	x	
Blood tests (complete) (Hb, Na, K, Cl, Ca, P, Mg, BUN, creatinine, GOT, γ-GT, LDH, AP, VBGA, folate, B12 vitamin)					x		x		x		x		x			x					x					x
PSA (only in case of prostate cancer)	x				x						x		x			x					x					x
Conventional chest X-ray (only if not chest CT)		x	x	x	x		x																			
Bone scan (only if ≥pT3 or pT1-4 pN+)		x	x	x																						
CT scan of chest/abdomen/pelvis (only if ≥pT3 or pT1-4 pN+)		x	x	x																						
IVU with tomography/CT (only if previous, concomitant or multifocal bladder tumour pTa/T1)			x		x		x																			
Urine cytology after forced diuresis		x		x		x		x		x			x			x										
Urethral barbotage cytology		x	x	x	x		x																			
Kidney ultrasound	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Post-void residual urine	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Micturition protocol	x		x		x		x		x		x	x		x		x		x		x		x		x		x
Voiding questionnaire		x		x		x		x		x			x		x		x		x		x		x		x	

FIGURE 77.3 Proposed protocol incorporating oncologic, functional, and metabolic investigations for regular follow-up of patients undergoing radical cystectomy with extended pelvic lymph node dissection for bladder cancer and ileal orthotopic bladder substitution. AP, alkaline phosphatase; BUN, blood urea nitrogen; Ca, calcium; Cl, chloride; CT, computed tomography; GOT, glutamic oxaloacetic transaminase; Hb, hemoglobin; IVU, intravenous urography; K, potassium; LDH, lactate dehydrogenase; Mg, magnesium; Na, sodium; P, phosphorus; PSA, prostate-specific antigen; VBGA, venous blood gas analysis; γ-GT, gamma-glutamyltransferase.

Prevention of kinking at the reservoir outlet at the time of surgery and removal of any cause of outlet obstruction (such as urethral strictures, protrusion of ileal mucosa into the urethra or residual prostatic tissue) postoperatively in the case residual infected urine is noted, is preferable to lifelong clean intermittent catheterization. An early sign for incomplete voiding is infected urine, which, especially if recurrent, should prompt the treating physician to investigate possible causes primarily by endoscopy. If this active monitoring is accomplished, spontaneous voiding at 10 years postoperatively can be achieved in as high as 96% of patients with a bladder substitute (2).

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CHAPTER 78 ORTHOTOPIC URINARY DIVERSION USING AN ILEAL LOW-PRESSURE RESERVOIR WITH AN AFFERENT TUBULAR SEGMENT

FIONA BURKHARD AND URS E. STUDER

An ileal low-pressure orthotopic bladder substitute offers several significant advantages over other forms of orthotopic urinary diversion. One is the ease of surgery, as the operation can be performed by any urologist experienced in performing radical prostatectomy or cystectomy with an ileal conduit (1). The short ileal segment, approximately 55 cm, which is used to construct this bladder substitute, minimizes the risk of intestinal malabsorption. Both the terminal ileum and the ileocecal valve are preserved. The reservoir is constructed as a sphere, thus achieving a maximum volume-to-surface area ratio and maximum capacity from the selected bowel segment (2). Another advantage is the isoperistaltic afferent tubular segment with the end-to-side ureteroileal anastomosis at its proximal end. This allows resection of the distal ureters, including the paraureteral lymphatics, at a safe distance from the cancerous lesion in the bladder and reduces the risk of leaving distal ureters behind that may contain carcinoma in situ. Furthermore, the shorter the remaining ureters are, the better the blood supply at their distal end and the lower the risk of ischemic stricturing of the distal ureter. The peristalsis of the afferent ileal segment acts as a dynamic antireflux mechanism, and in cases of complicated urethral strictures or urethral tumor recurrence, the afferent tubular segment can easily be transformed into an ileal conduit. By slightly modifying this reservoir, it can be applied for bladder augmentation following subtotal cystectomy in patients with benign bladder pathologies.

SELECTION CRITERIA

Patients undergoing orthotopic bladder substitution will generally receive the diversion after cystectomy for bladder cancer. A full workup to stage the cancer is important as well as a cystoscopy to determine the extent of the cancer and exclude involvement of the urethra (negative preoperative biopsies from the prostatic urethra [male]/ bladder neck [female]). As is true for all bladder substitutes, specific selection criteria need to be adhered to. In general, metastatic disease should be ruled out. Adequate renal function defined by a glomerular filtration rate >50 $mL/min/m^2$ precludes the need for lifelong bicarbonate supplementation and liver function should be normal (aspartate aminotransferase, alanine aminotransferase). Patients should not have active inflammatory bowel disease or have undergone previous extensive bowel resection (malabsorption). It is important that patients have the mental and physical ability to learn to live with a bladder substitute (comply with voiding intervals, mobility to get to toilet also at night). They also have to be willing to comply with routine follow-up.

INDICATIONS FOR SURGERY

Orthotopic diversion represents the procedure of choice in the properly selected patient undergoing cystectomy. However, as with all bladder substitutes, oncologic outcome and complete resection of the cancer must in no way be compromised by the orthotopic reconstruction. In addition, the external rhabdosphincter and internal lissosphincter complex and their corresponding innervation must remain functionally intact. The ileal orthotopic bladder substitute is particularly well suited for patients in whom the sequelae of ileocecal resection should be avoided.

ALTERNATIVE THERAPIES

Alternatives to the ileal orthotopic bladder include other forms of diversion, including ileal and colon conduits, continent urinary diversions, and other orthotopic diversions.

SURGICAL TECHNIQUE

Cystectomy

Pelvic lymphadenectomy and cystectomy are performed according to standard technique, with slight modifications (3). The external iliac vessels, the obturator fossa, and the hypogastric vessels are completely freed of all lymphatic, fatty, and connective tissue on both the medial and lateral side. After dividing the dorsolateral bladder pedicles, which contain the superior and inferior vesical vessels, close to the hypogastric arteries, the pelvic floor fascia is incised and the Santorini plexus is ligated. The prostatic vessels should be preserved on the non–tumor-bearing side to ensure adequate blood supply to the pelvic plexus and neurovascular bundle.

The ureters are divided where they cross the iliac vessels. This allows en bloc removal of the distal ureters and paraureteral lymphatic vessels, together with the cystectomy specimen. The dorsomedial pedicle is resected along the pararectal-presacral plane on the tumor-bearing side. Whenever possible, care is taken to preserve the hypogastric nerve fibers and the pelvic plexus, which are situated dorsolateral to the seminal vesicles, on the contralateral non–tumor-bearing side. On this side, the dissection along the dorsolateral wall of the seminal vesicles is stopped at the base of the prostate. The neurovascular bundle is then detached from the prostatic capsule in a retrograde fashion. The Santorini plexus is then divided, and the membranous urethra is transected as close as possible to the apex of the prostate by excavating it out of the donut-shaped apex.

Preparation of the Ileum Segment for the Bladder Substitute

For construction of the reservoir, an approximately 55-cm long ileal segment is isolated 25 cm proximal to the ileocecal valve (Fig. 78.1). The length of the ileal segment is measured with a ruler in portions of 10 cm along the border of the mesoileum without stretching the bowel. Irritation of the bowel as well as epidural anesthesia with local anesthetics should be avoided because this can increase smooth muscle tone and activity and thereby "shorten" the bowel, resulting in a measured segment which will be too long after muscle relaxation.

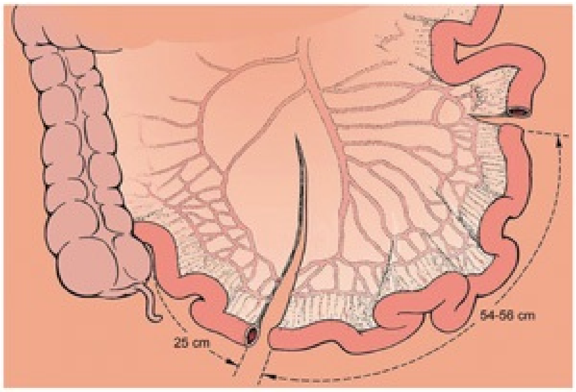

FIGURE 78.1 An approximately 55-cm long ileal segment for the bladder substitute is isolated 25 cm proximal to the ileocecal valve. Note the long incision distally (eases reanastomosis of the ileum and mobilization of the reservoir) and the short incision in the mesoileum proximally (preserves blood supply to the reservoir).

The incision of the mesoileum at the distal or aboral end of the ileal segment is long and transects the communicating vessels between branches of the superior mesenteric artery and the ileocecal artery. In contrast, the proximal incision must be short in order to preserve the main vessels perfusing the future reservoir segment. Bowel continuity is restored with a 4-0 running polyglycolic acid suture incorporating only the seromuscular layer. The mesoileum borders are adapted with a running suture (2-0 polyglycolic acid) in which the mesoileum of the bladder substitute is included (Fig. 78.2). The sutures must be applied superficially, taking care to preserve the blood supply to the bladder substitute. Both ends of the isolated ileal segment are closed by seromuscular running sutures (4-0 polyglycolic acid). The distal end of the ileal segment, approximately 40 to 45 cm long, is opened along its antimesenteric border (see Fig. 78.2), leaving a 10- to 12-cm afferent tubular limb into which the ureters are implanted.

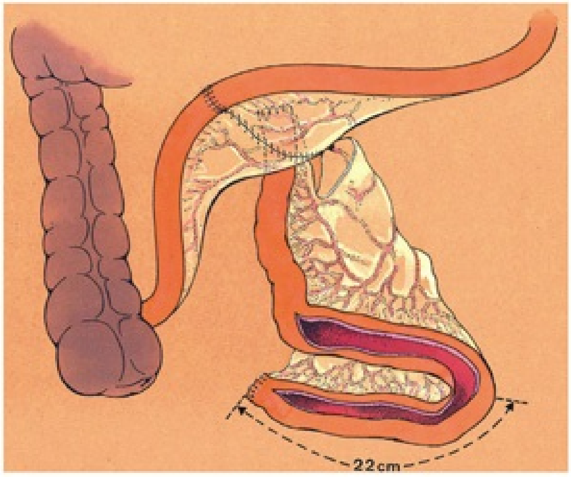

FIGURE 78.2 Bowel continuity is restored with a continuous end-to-end suture incorporating only the seromuscular layer. The incision in the mesoileum is closed; deep sutures are avoided in order not to compromise circulation. Both ends of the isolated ileal segment are closed by seromuscular running sutures. The distal two-thirds of the ileal segment are opened along its antimesenteric border.

Ureteroileal End-to-Side Anastomosis

The left ureter is mobilized up to the lower pole of the kidney, with care taken to maintain its surrounding blood supply and thereby prevent ischemia. It is then brought without tension to the right side of the abdomen retroperitoneally by crossing the aorta slightly above the inferior mesenteric artery. Note: If the ureters need to be resected close to the kidney (e.g., if there is carcinoma in situ, compromised vascular supply, or previous radiation history), a longer afferent ileal segment can be harvested to bridge the necessary distance. Transpose the opened part of the ileal segment onto the patient’s upper abdominal wall, with the proximal end of the afferent tubular segment hanging into the abdominal cavity at the level of the common iliac vessels (Fig. 78.3). The ureters are spatulated over a length of 1.5 to 2.0 cm. Incisions (2 cm) are made in the most proximal portion of the afferent tubular ileal segment along the paramedian antimesenteric border. The spatulated ureters are implanted using the Nesbit technique in an open end-to-side fashion using running sutures (Fig. 78.4). To prevent bowel ischemia between the ureteral anastomoses, the right ureter is placed approximately 1 cm distal to the left ureter.

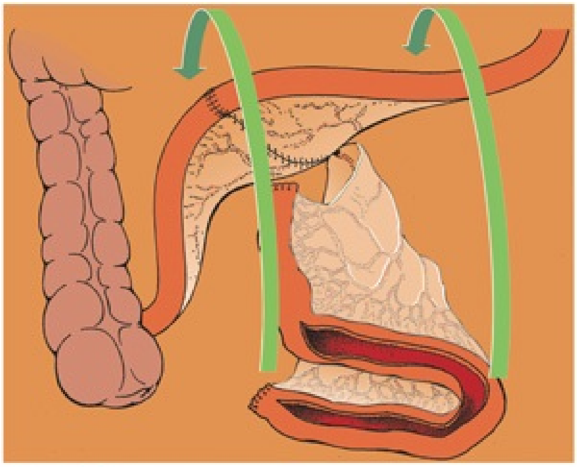

FIGURE 78.3 Transpose the divided ileum for the reservoir onto the upper abdomen as shown by the *arrows*. The proximal part for the afferent tubular segment remains in the abdominal cavity.

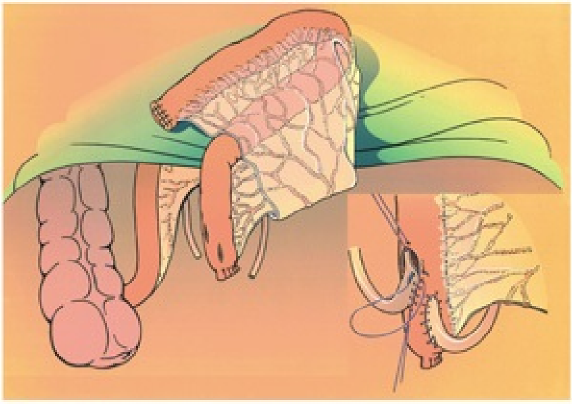

FIGURE 78.4 Two slightly staggered incisions (2 cm) are made in the most proximal portion of the afferent tubular ileal segment along the paramedian antimesenteric border. The ureters are spatulated over a length of 1.5 to 2.0 cm. A ureteroileal anastomosis using an end-to-side Nesbit technique with a 4-0 running suture ensures a low stricture rate.

The ureters are stented with 7Fr or 8Fr catheters. To prevent dislocation of the catheters, a rapidly absorbable suture (5-0 polyglycolic acid) is placed through both the ureter and the catheter 3 to 4 cm proximal to the anastomosis. It is tied loosely to avoid compromising the ureteral blood supply. The most distal periureteral tissue is sutured to the afferent ileal segment to both relieve tension on the anastomosis and to cover it. The ureteral catheters are passed through the wall of the most distal end of the afferent tubular segment, where it is covered by some mesoileum. This provides a "covered" channel in the reservoir wall when withdrawing the ureteric catheters 4 to 7 days postoperatively.

Construction of the Bladder Substitute and Anastomosis to the Urethra

To construct the reservoir itself, the two medial borders of the opened U-shaped distal part of the ileal reservoir are folded to form a U and sewn together with a single continuous seromuscular layer of 2-0 polyglycolic acid suture (Fig. 78.5). The bottom of the U is then folded up between the two ends of the U (see Fig. 78.5), resulting in a spherical reservoir consisting of four cross-folded ileal segments. After closure of the lower half of the anterior wall and part of the upper half (Fig. 78.6), the surgeon's finger is introduced through the remaining opening to determine the most caudal part of the reservoir. At this point, a hole of 8 to 10 mm in diameter is cut out of the pouch wall, outside the suture line (Fig. 78.7). Importantly, although it may appear easier to perform, it is imperative that the anastomosis of the urethra to the neobladder is not to the funnel-shaped end of the reservoir. This increases the risk of kinking and obstruction at the anastomotic site when the reservoir is full (Fig. 78.8). To achieve optimal voiding, the anastomosis must sit broadly on the pelvic floor. After placement of a silicone 18Fr Foley urethral catheter, six 2-0 Vicryl sutures anastomose the previously made hole in the bladder substitute with the urethra (Fig. 78.9). Two posterior sutures are placed medial to the neurovascular bundles including a generous portion of Denonvilliers fascia, and two anterolaterally to these through the lateral portion of the urethra, and two anteriorly, taking only a small part of the urethra but including the ligated Santorini plexus and the puboprostatic ligaments (Fig. 78.10). When the urethral sutures are placed, the needle incorporates 3 to 4 mm of the sphincter but exits at the mucosal edge, thereby bringing them close to the mucosal edges of the reservoir. The aim is to anchor the reservoir to Denonvilliers fascia and the puboprostatic ligaments thereby minimizing tension on the anastomosis and avoiding shortening of the urethral length. Adherence to these steps also reduces the incidence of anastomotic strictures. The following maneuvers can be applied to help bring the reservoir down to the pelvic floor without tension: Place the mesoileum in the upper abdomen, pull the sigma upward to make space for the reservoir, and gently pull the mesoileum of the reservoir down toward the pelvic floor (Fig. 78.11). If necessary, the operating table is now flexed to reduce the distance between the bladder substitute and the urethra. By tying the anterior stitches of the ileourethral anastomosis first and then the lateral sutures and finishing with the posterior sutures, the reservoir is anchored anteriorly and tension on the posterior sutures is reduced. Sutures are tied loosely to prevent cutting, ischemia, and stenosis. If necessary and this is seldom the case, two stitches can be placed lateral to the urethra to fix the bladder substitute to the pelvic floor thereby preventing undue traction on the anastomosis.

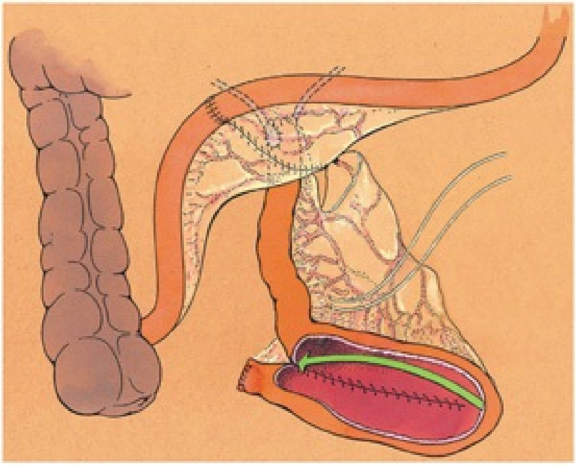

FIGURE 78.5 The two medial borders of the antimesenteric opened U-shaped distal ileum segment are oversewn with a single-layer seromuscular running suture. The bottom of the U is folded back to the two ends of the U to form a sphere as shown by the *arrow*. Note placement of the ureteral stents through the mesoileum.

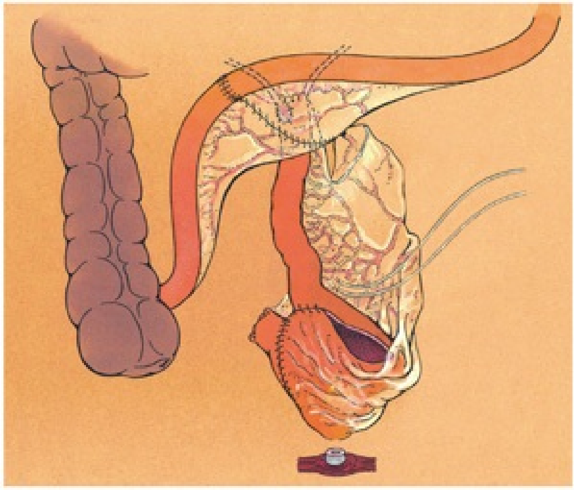

FIGURE 78.6 The caudal half of the remaining reservoir opening is closed completely, and the cranial half partially by a running seromuscular suture.

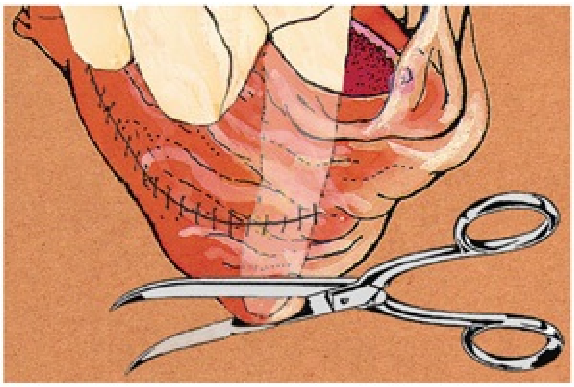

FIGURE 78.7 The surgeon's finger is introduced to determine the most dependent part of the reservoir, and an 8- to 10-mm diameter hole is excised.

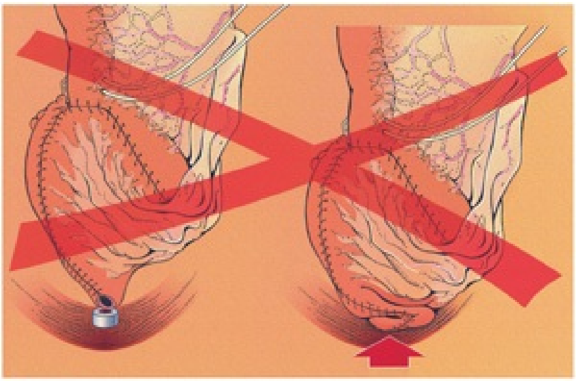

FIGURE 78.8 Anastomosis of the neobladder to the urethra is not made using the funnel-shaped end of the reservoir, as this leads to kinking and outlet obstruction (as shown by the arrow).

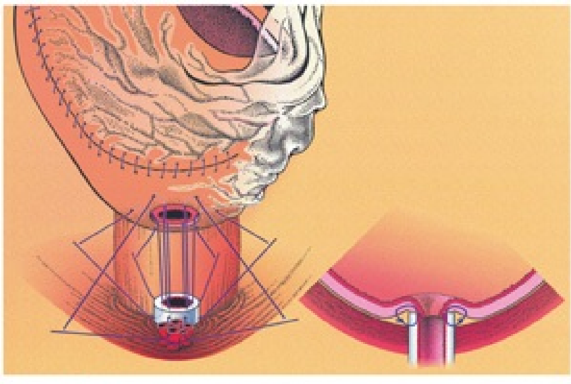

FIGURE 78.9 Six 2-0 Vicryl sutures anastomose the previously made hole in the bladder substitute to the urethra.

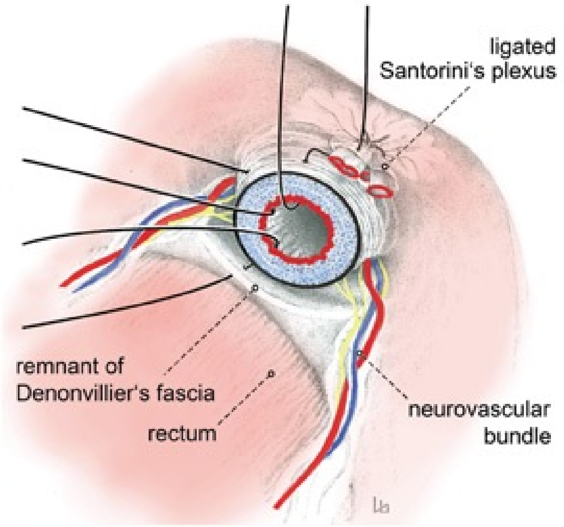

FIGURE 78.10 Two posterior sutures are placed medial to the neurovascular bundles including a generous portion of Denonvilliers fascia, two anterolaterally thereof through the lateral portion of the urethra, and two anteriorly, taking only a small part of the urethra but including the ligated Santorini plexus and the puboprostatic ligaments.

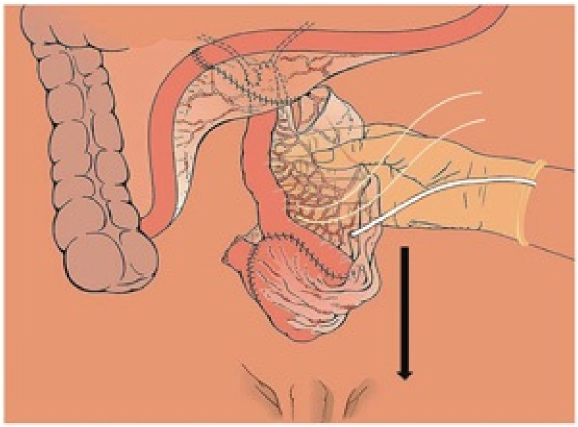

FIGURE 78.11 To aid bringing the bladder substitute down to the pelvic floor, gently pull on the root of the mesoileum of the bladder substitute.

Before complete closure of the reservoir, a cystostomy tube is passed through the wall of the bladder substitute and positioned so that its exit site is covered with mesenteric fat (Fig. 78.12).

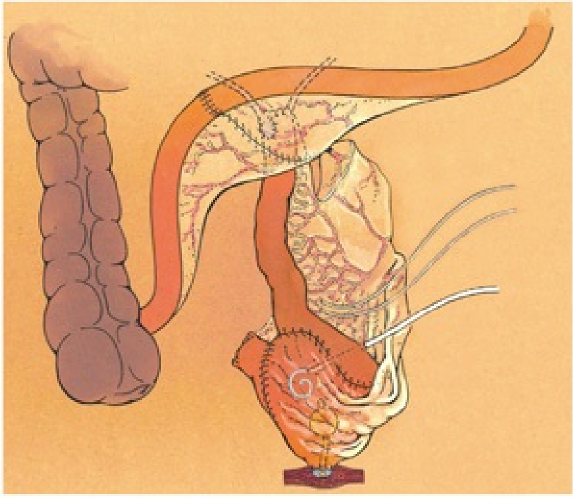

FIGURE 78.12 After insertion of a 10Fr cystostomy tube, the reservoir is closed completely.

Surgical Modifications for Obese Patients

An ileal neobladder can successfully be constructed and brought down into the pelvis of obese patients. A measure of whether the reservoir will work in obese patients is if the bowel 12 cm from the distal end of the harvested segment is able to reach the base of the penis. To ensure this will happen, the following steps should be employed. First, extend the distal mesenteric incision deeper into the mesentery; this will provide for increased mobility. If necessary, the serosa can be incised transversely at different levels, the incision has to be very superficial to avoid damaging the vessels (Fig. 78.13). In the case of obese patients, limit the amount of ileum used for construction of the reservoir as cross-folding of the thick mesoileum can be difficult. To decrease the thickness, fatty tissue between the distal vascular arcades can be removed.

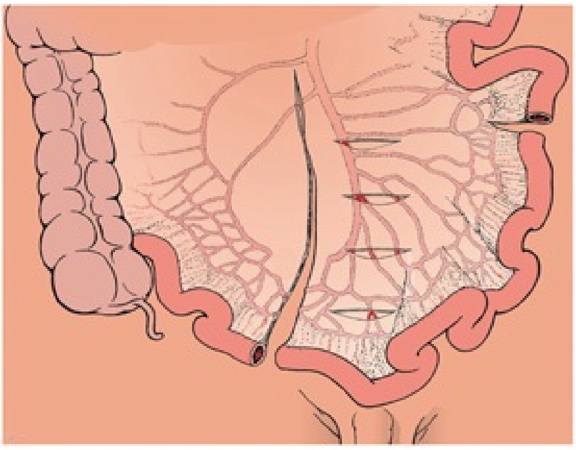

FIGURE 78.13 The distal mesenteric incision can be extended deeper into the mesentery and superficial transverse incisions of the serosa can be made to achieve more length.

Postoperative Care

Critical components to good long-term results include the ability to create a high-compliance, low-pressure reservoir with an effectual continence mechanism, as well as patient compliance and meticulous postoperative care. Ureteral stents are removed after bowel activity has resumed about 5 to 7 days after surgery. At 8 to 10 days postoperatively and after pouchography documents no evidence of urinary leakage, the cystostomy tube is removed. The Foley catheter remains for an additional 2 days to provide adequate time for closure of the cystostomy channel in the reservoir wall. Although our patients are on antibiotics, all drains are removed as early as possible to prevent infections. After the patient is drain-free, any bacteriuria is treated with antibiotics until the urine is sterile.

Patients are carefully instructed on how to void. Initially, they are instructed to empty the pouch every 2 hours during the daytime in a sitting position by relaxing the pelvic floor and increasing intra-abdominal pressure. At night, they are told to use an alarm clock to void every 3 hours. In the early phase, the urine is often hypo-osmolar; consequently, the bladder substitute will secrete sodium chloride, resulting in a salt-losing syndrome and therefore hypovolemia and metabolic acidosis. To prevent this series of metabolic events, patients are instructed to consume at least 2 L of liquid a day and to increase salt intake. They are prophylactically placed on sodium bicarbonate (2 to 6 g per day) after ureteral stent removal with the aim to attain a venous base excess between 0 and +2. Blood gas and body weight should be assessed at regular intervals during the initial phase after catheter removal.

Thereafter, patients without metabolic acidosis (no negative base excess) or those managed appropriately with oral intake of sodium bicarbonate are instructed to gradually increase their micturition intervals from 3 to 4 hours in order to obtain a bladder capacity of up to 500 mL. When adhering to these prolonged micturition intervals, increased pouch pressures may result in incontinence, but the elevated pressures are essential to increase the reservoir's capacity. Therefore, patients are advised to refrain from voiding when they experience incontinence, as otherwise, the bladder substitute will never achieve the desired capacity. Our patients are followed regularly every 6 months for the first 5 years and then at yearly intervals.

With increasing capacity, nighttime continence will improve; however, a reservoir capacity of >500 mL should be avoided. Overdistention of the reservoir will result in a floppy bag that is unable to empty adequately with increased residual urine, and the potential to develop urinary retention. Residual urine should be monitored, recognized early, and managed promptly. The cause of residual urine needs to be addressed (urethroscopy), and in the case of outlet obstruction, the obstructing tissue is incised or resected (4). Bacteriuria should be treated appropriately.

OUTCOMES

Complications

We published our 20-year experience with the ileal neobladder in 2006 (5). In our experience, early diversion-related complications (within 30 days) occurred in 13% of patients. Pyelonephritis was the predominant complication noted (5.8%). In a recent prospective randomized controlled trial, we were able to show that early complications can be significantly reduced by intraoperative fluid management. A restrictive fluid management combined with norepinephrine administration resulted in significantly less blood transfusions, major early complications, and a shorter hospital stay (6).

Diversion-related late complications (>30 days) that required rehospitalization were metabolic acidosis, pyelonephritis, and sepsis in 4.4%, 3.9%, and 2.1%, respectively, and urinary retention due to infection and consequent mucus production in 4.5% (4). Typical late complications requiring surgery were bladder substitute outlet obstruction in 12% and incisional or inguinal hernias in 10%.

A decline in renal function is observed in approximately 21% of patients with a bladder substitute (BS) after 10 years, which is lower than the 36% in patients with ileal conduits (IC) (7). In this retrospective study, obstruction was the leading and an independent risk factor for renal function deterioration in both IC and BS patients in a logistic regression analysis. In patients with diabetes or hypertension and an IC, the risk of experiencing a deterioration in renal function was significatly higher than in patients with a BS.

Functional Results

The technique described here has been performed at our institution for 30 years in more than 700 patients. Nerve sparing and a standardized technique has allowed for a gradual improvement of results. The majority of patients (>90%) void spontaneously and do not require intermittent self-catheterization. Ninety percent are continent during the day and 78% during the night when adhering to 3 to 4 hourly voiding intervals both during the day and night. Less than 10% require intermittent self-catheterization or have indwelling catheter for nursing home reasons. In addition to the performing the earlier detailed surgical technique correctly, meticulous postoperative care and follow-up is a prerequisite for successful outcome with this method of bladder substitution.

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CHAPTER 79 ILEAL NEOBLADDER

RICHARD E. HAUTMANN

SURGICAL TECHNIQUE

Cystectomy (Radical Cystectomy)

This radical cystectomy (RC) section is restricted only to those parts that are essential for good function of the neobladder.

Modifications of pelvic lymphadenectomy and the approach to the pelvic ureter are made to allow for optimum ileal neobladder construction (1–4). Pelvic lymphadenectomy and RC are performed according to standard technique with modifications. Ideally, the ileal neobladder anatomically replaces the native bladder (i.e., it is located extraperitoneally in the pelvic cavity) and ileourethral anastomoses are located also extraperitoneally. Depending on tumor stage and location, this goal can be easily achieved by the creation of two large peritoneal flaps obtained from the visceral pelvic peritoneum (Fig. 79.1).

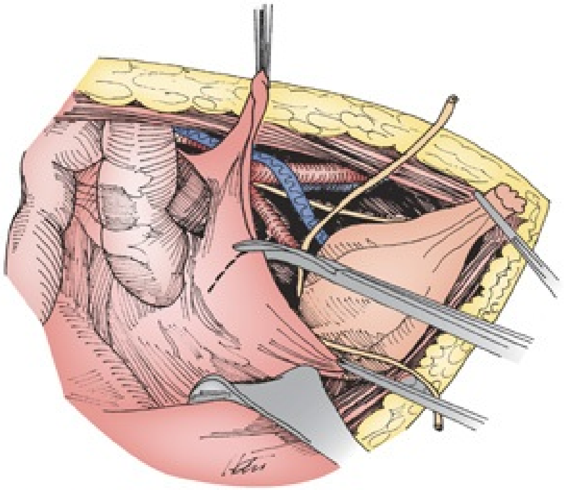

FIGURE 79.1 Modified pelvic lymph node dissection has been completed. Ureters are exposed extraperitoneally. The peritoneum over the bladder is bisected to create two large peritoneal flaps for later total extraperitonealization of the ileal neobladder.

Ureteral Mobilization

The standard vertical incision lateral to the sigmoid mesocolon should not be used. The peritoneal sac should be mobilized medially on both sides. The surgeon should continue to locate the ureter extraperitoneally, realizing that it is displaced during exposure because it adheres to the peritoneum (see Fig. 79.1). The ureters are mobilized with sufficient periureteral adventitia in a cephalad direction on both sides. A plane is established between the ureter and the lateral pedicles of the bladder. As the ureter and bladder are retracted medially, the lateral pedicle is exposed. Finally, the ureter is clamped distally. Fine-traction sutures are inserted in the proximal surface of the ureter, and it is divided against the clamps with scissors. Then, the ureter is dissected proximally so that not more than 3 to 6 cm are free.

Depending on tumor stage and location, the bladder is completely extraperitonealized, and the peritoneum is bisected over the bladder (see Fig. 79.1). If this cannot be done safely, an incision in the peritoneum is made high on the base of the bladder, leaving a peritoneal patch on the posterior bladder wall.

Approach to the Membranous Urethra in the Male Patient

Special details other than those described in Chapter 19 (RC in men) and Chapter 20 (RC in women) that are critical for a perfect outcome including preservation of the erectile function are presented here.

We describe a new technique for nerve-sparing RC and orthotopic diversion with preservation of the vasa deferentia, seminal vesicles, and neurovascular bundles (NVBs). No prostatic tissue is left behind, thus eliminating the risk of local recurrence from bladder cancer as well as de novo prostate cancer (5).

RC is begun with an intrafascial prostatectomy, which is done in a retrograde fashion. For optimal protection of the NVB and to avoid damage to the autonomic nerves running into the membranous urethra, a “high-release” approach with incision of the endopelvic and periprostatic fascia and bunching of Santorini plexus at the level of the prostate and not distal to it is of utmost importance (Figs. 79.2 and 79.3). The dorsolateral NVB can be separated from the prostatic capsule, or the prostatic capsule can be left in place. The prostatic apex is approached laterally directly along the prostatic capsule, and the membranous urethra is delivered sharply out of the donut-shaped prostatic apex to avoid nerve damage on the dorsolateral side of the urethra and to maintain maximum urethral length.

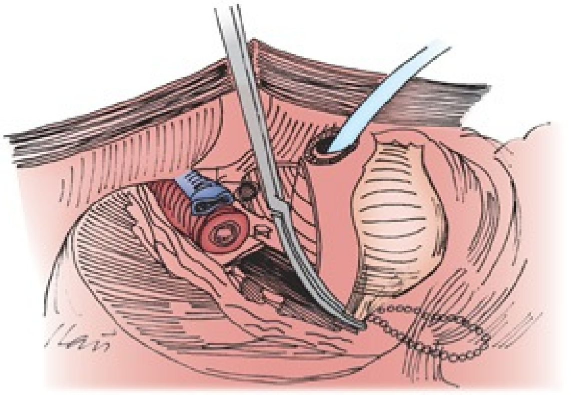

FIGURE 79.2 Standard dissection laterally to the prostatic fascia to free the NVBs from the prostate and the lateral surface of the seminal vesicles carries a high risk to ruin the erectile function by injuring these nerves.

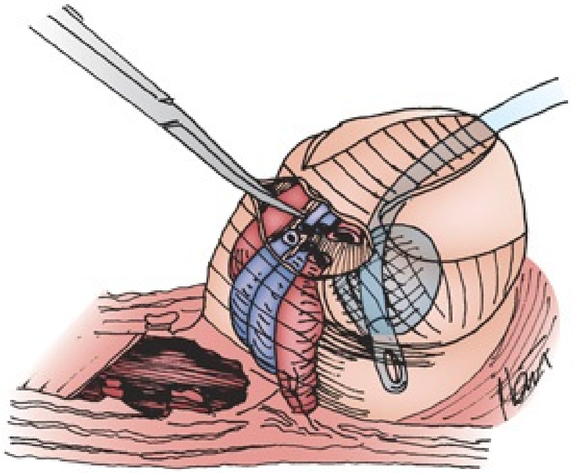

FIGURE 79.3 The radical cystectomy is begun as a standard nerve-sparing radical prostatectomy, with high release of the NVBs. Gentle traction is exerted on the balloon catheter to extrude the vesical neck. Denonvilliers fascia is opened with a short transverse incision over the ampullae of the vases and the base of the vesicles. After transection of vesicles and ampullae, an easy cleavage plane is developed between the trigone and catheter balloon anteriorly and the vesicles posteriorly until the cul-de-sac has been reached.

Despite the intrafascial approach, Denonvilliers fascia very often remains on the posterior surface of the prostate specimen where it is fused with the prostatic capsule in the midline. At the base of the prostate, a 2- to 3-cm transverse incision of Denonvilliers fascia is carried out, and both the vases and the seminal vesicles are transected (Fig. 79.4). A cleavage plane is easily developed anterior to the ampullae/seminal vesicles and dorsal to the trigone. The balloon of the transurethral catheter serves a control because it is easily palpated. In this fashion, most of the NVB are spared. The ascending cleavage plane easily reaches the cul-de-sac, with the inferior bladder pedicles still intact.

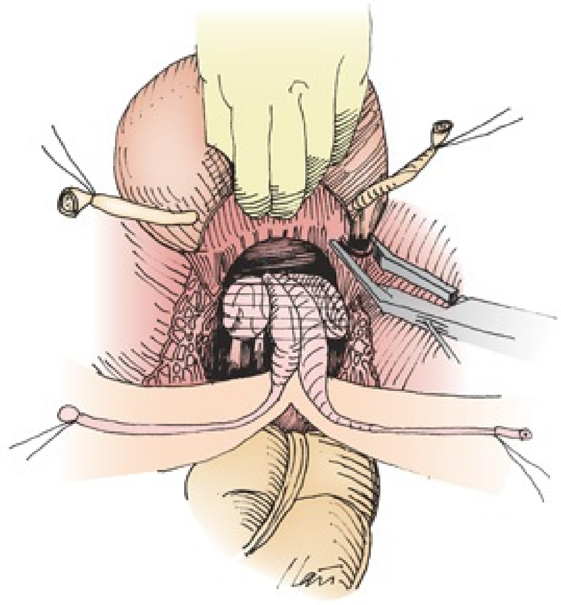

FIGURE 79.4 Posterior view. The plane anterior to seminal vesicles/ampullae of the vases and dorsal to the prostate has been developed. The posterior pedicle of the bladder is transected 3 cm ventral to the NVBs.

The remainder of the RC can be done in an ascending or descending fashion. The latter seems to offer better control of the bundles. The vases are identified and left on the pelvic peritoneum. The peritoneum is incised transversely 5 cm anterior to the cul-de-sac. Care is taken to enter the plane between posterior bladder wall ventrally and the vases and seminal vesicles dorsally (Fig. 79.5).

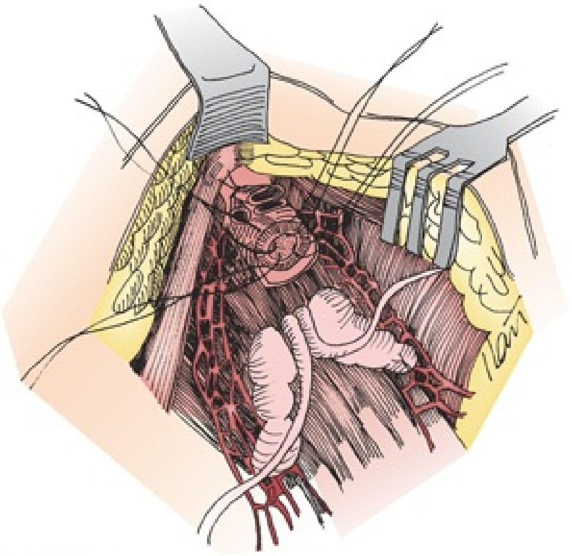

FIGURE 79.5 Final situation. NVBs covered and protected by seminal vesicles.

Approach to the Female Urethra

This is absolutely critical if an orthotopic neobladder is considered. Helpful tricks are as follows: Preparation of the urethra requires special attention to surgical detail to avoid damage to the proximal urethra, anterior vaginal wall, urethral support, and NVB, which could jeopardize the continence mechanism and micturition. This is particularly true when a nerve-sparing approach is planned (2).

This step is greatly facilitated when a povidone-iodine pack is placed into the vagina and the urethra rides on top of the anterior vaginal wall (Fig. 79.6). It is not sufficient just to put sponge stick into the vagina. Packing the vagina snugly has four distinct advantages:

1. The firm urethra is palpable at all times.
2. The urethra is lifted out of the depth of the pelvic cavity into the center of the operative field.
3. The NVBs slip downward and are no longer at risk.
4. The urethra (catheter) rides on top of the vagina and is visible and palpable at all times.

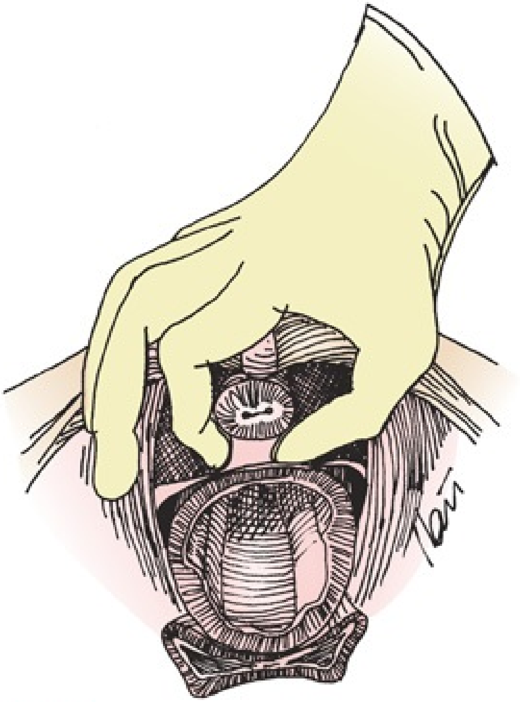

FIGURE 79.6 Packed vagina gives ideal exposure to urethra and pelvic support structures.

The endopelvic fascia is incised immediately lateral to the posterior urethra at the urethrovesical junction (Fig. 79.7). As much of the urethra at the urethropelvic ligament and paraurethral vascular and nerve plexus as possible must be saved.

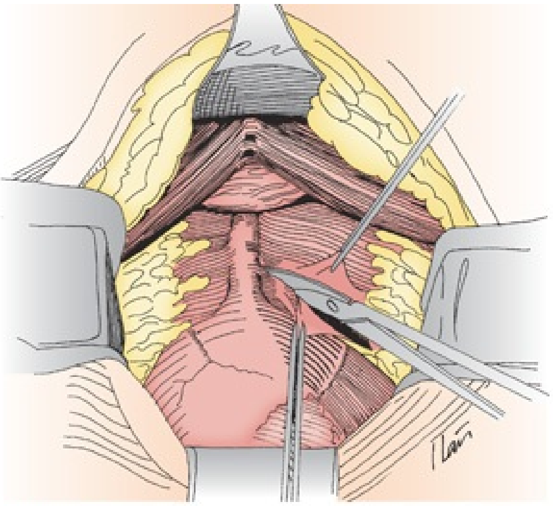

FIGURE 79.7 Urethral support-sparing cystectomy in women. Incision of endopelvic fascia is parallel to posterior urethra and urethrovesical junction.

The proximal urethra is carefully (little sponge stick) prepared. Most surgeons do not transect the urethra, but the bladder neck, assuming that the external sphincter mechanism is located in the proximal urethra. However, this is not the case. An extraordinary helpful trick to find the correct site for urethral transection is to inflate the balloon of the transurethral catheter to 50 mL, pull it into the bladder outlet, and to ligate proximal urethra and catheter before transection (Fig. 79.8).

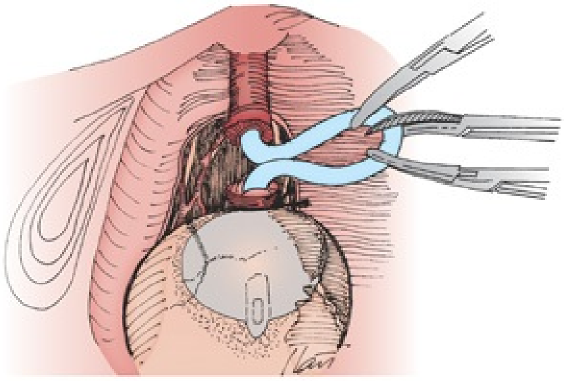

FIGURE 79.8 Balloon with 50 mL inflated. Proximal urethra including catheter ligated just distal to bladder neck. No bladder neck left behind.

As the proximal urethra is transected, six interrupted 2-0 polyglycolic acid sutures are placed circumferentially in the urethra (Fig. 79.9). Frozen sections for pathologic examination are taken from the urethra/bladder neck to identify carcinoma in situ or overt carcinoma, which would result in subsequent urethrectomy.

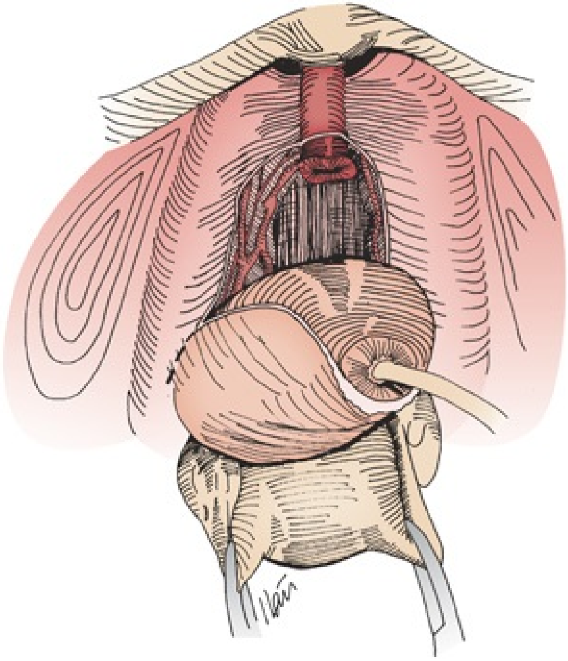

FIGURE 79.9 Urethra transected. Plane between specimen and anterior vaginal wall developed. NVBs/suspensory ligaments well prepared.

Next, the bladder neck is carefully dissected of the anterior vaginal wall. Upward traction of the specimen facilitates dissection between lateral bladder wall and supporting structures that must not be jeopardized. The urethrovesical junction is dissected off of the anterior vaginal wall down to the posterior bladder wall (see Fig. 79.9).

The remainder of the RC is done in a descending fashion. The cardinal ligaments are divided anteriorly to avoid the pelvic plexus. The superior vesical artery and the uterine vessels are cross-clamped, tied, and cut. Once the uterine artery is transected, the distal ureter comes into view and can be isolated to avoid damage to the nerve fibers. The vaginal cavity is entered by a transverse incision, and the edges of the vaginal incision are held open with Allis clamps (Fig. 79.10). The distal stump of the ureter following its division is pulled medially to facilitate dissection of the lateral bladder wall.

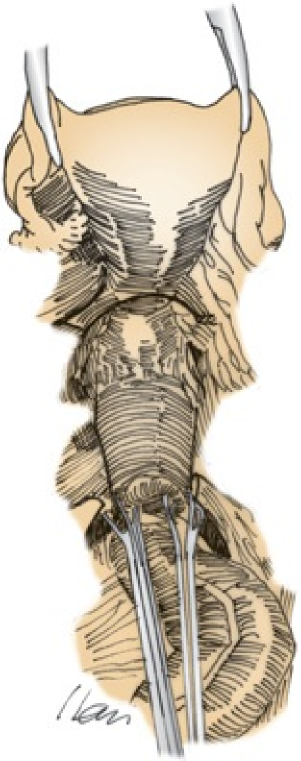

FIGURE 79.10 Posterior view. Uterosacral ligaments on both sides are divided. Edges of transverse incision in posterior fornix of vagina are held under gentle traction with Allis clamps. Posterior bladder wall is dissected off anterior vaginal wall down to bladder neck. Autonomic nerve fibers (inferior hypogastric plexus), which run laterally to vessels, are separated from lateral wall of bladder and vagina.

Figure 79.11 shows the final result with a remarkably small excisional defect and ideally saved anterior vaginal wall. The suspensory ligaments of urethra and vagina are fully intact (Fig. 79.12). Figure 79.12 shows neobladder on top of vagina anastomosed to the urethra.

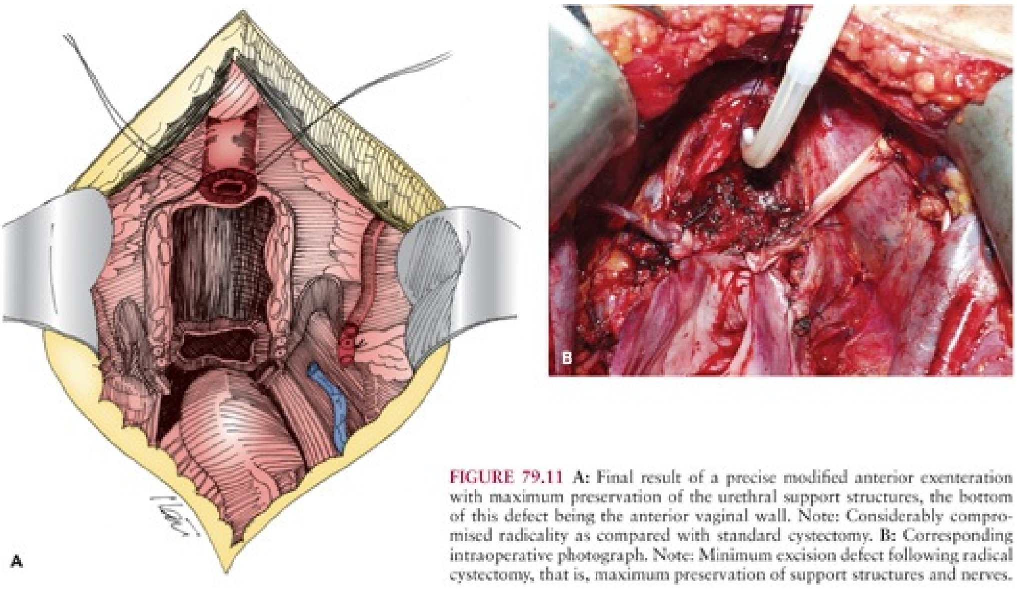

FIGURE 79.11 A: Final result of a precise modified anterior exenteration with maximum preservation of the urethral support structures, the bottom of this defect being the anterior vaginal wall. Note: Considerably compromised radicality as compared with standard cystectomy. B: Corresponding intraoperative photograph. Note: Minimum excision defect following radical cystectomy, that is, maximum preservation of support structures and nerves.

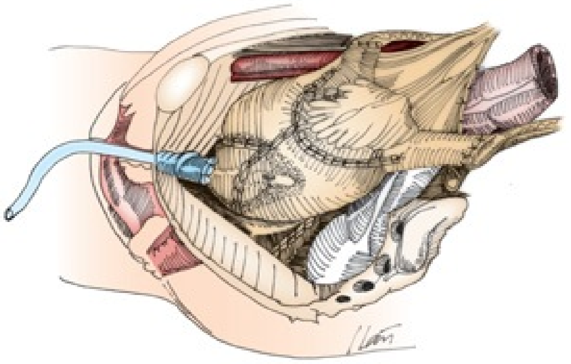

FIGURE 79.12 Final situation: neobladder on top anterior vaginal wall. Ileoureteral anastomoses above common iliac vessels. Left ureter courses lateral to sigmoid in its physiologic bed. Extraperitonealization of neobladder to follow (see Fig. 79.1).

Construction of the Reservoir

The light behind the mesentery should be adjusted, and a 60- to 70-cm long ileal segment should be selected 10 to 20 cm proximally from the ileocecal valve (2,6,7). Spasticity of the bowel or a thick, short mesentery may lead to more bowel than necessary, thus increasing the reservoir capacity. It is helpful to place two temporary stay sutures at the intended resection lines. They can be moved several times if necessary. The most dependable part of the segment should be long enough to reach the top of the symphysis pubica in the skin level. That point should be marked with a suture. This maneuver guarantees that the reservoir will reach the urethral remnant without difficulty. The distal division of the mesentery along the avascular region between the ileocolic artery and the terminal branches of the superior mesenteric artery should extend to the base of the mesentery to provide maximum mobility and sufficient length to reach the membranous urethra. The proximal incision of the mesentery is made as short as possible to provide maximum vascular supply to the ileal segment. The ileum is then divided between bowel clamps. A standard bowel anastomosis is performed, and the mesenteric trap is closed. The isolated bowel segment is thoroughly cleaned or rinsed with saline or an iodine solution (Fig. 79.13).

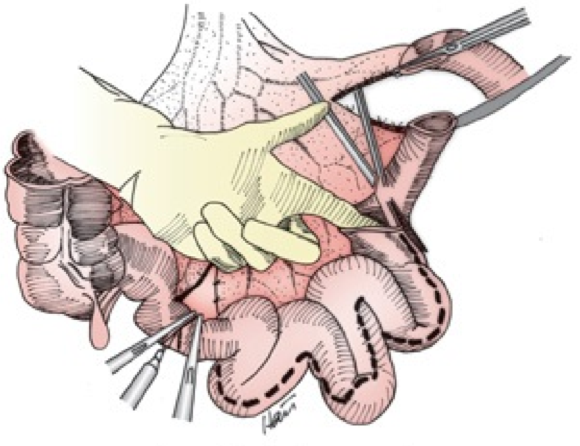

FIGURE 79.13 Selection of the ileal segment with an appropriate vascular supply and antimesenteric incision of ileum, except for the small chimneys on both sides of the W and the intended site of the ileourethral anastomosis (*broken line*).

Four lengths of ileum are arranged in the shape of a W with 3- to 5-cm long chimneys on each side of the W using five to six Babcock clamps or traction sutures. Other than the two chimneys, the bowel is opened on the antimesenteric border except for a 5- to 7-cm section centered around the marking suture, which is opened close to the antimesenteric border to create a U-shaped flap. Two to

3 cm from the tip of that flap, a buttonhole of all layers is excised from the ileal plate. An ileal plate is formed by sewing together the cut edges of the antimesenteric borders of the W using 2-0 synthetic absorbable sutures (SASs) on a straight needle (Fig. 79.14).

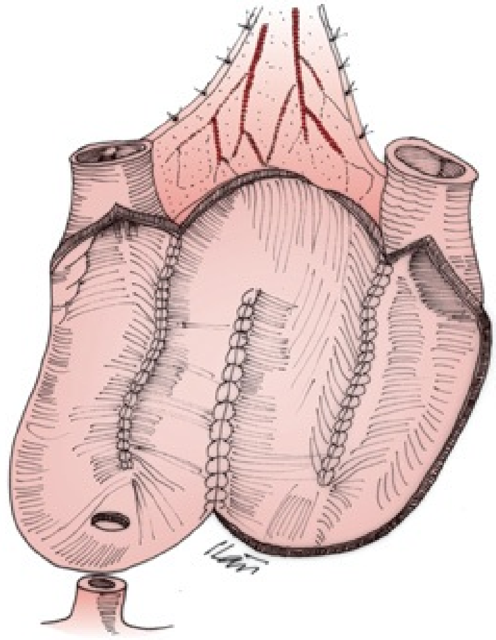

FIGURE 79.14 W-shaped reconfiguration of the intestinal segment after detubularization and asymmetrical incision of the ileal wall at the site of the anastomosis to the urethra, forming a U-shaped flap.

A 22Fr catheter is placed through the buttonhole. For the actual anastomosis, six previously placed double-armed sutures using 3-0 SAS in the urethra are used. The inner sutures are passed through the neobladder outlet in the ileal plate without grasping the ileum, and the corresponding outer sutures grasp the entire ileal wall 5 to 8 mm lateral to the neobladder outlet (Fig. 79.15). This guarantees a wide, ideal, funnel-shaped anastomosis so that mucosa is in direct contact with urethral epithelium. Next, under gentle traction on the transurethral catheter, the ileal plate is manipulated down to the urethral remnant, and the knots are tied inside the bowel (Fig. 79.16). The cut edges of the 5- to 7-cm U-shaped flap are sewn together over the catheter. The lower third of the anterior wall of the neobladder is closed, beginning inferiorly with interrupted 3-0 SAS (Fig. 79.17).

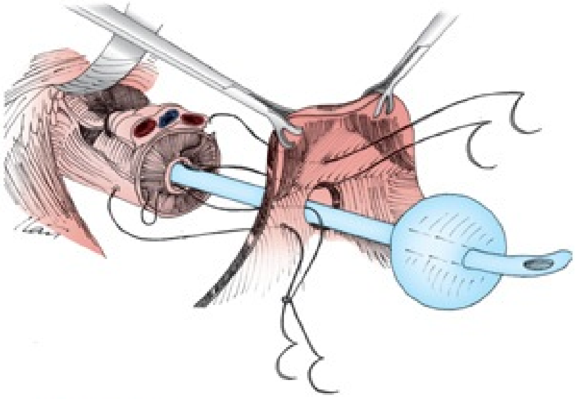

FIGURE 79.15 Ileourethral anastomosis, anterior view.

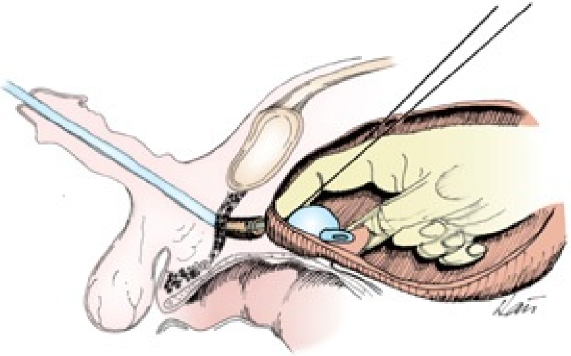

FIGURE 79.16 Lateral aspect of the ileourethral anastomosis. The sutures are tied from inside the ileal neobladder.

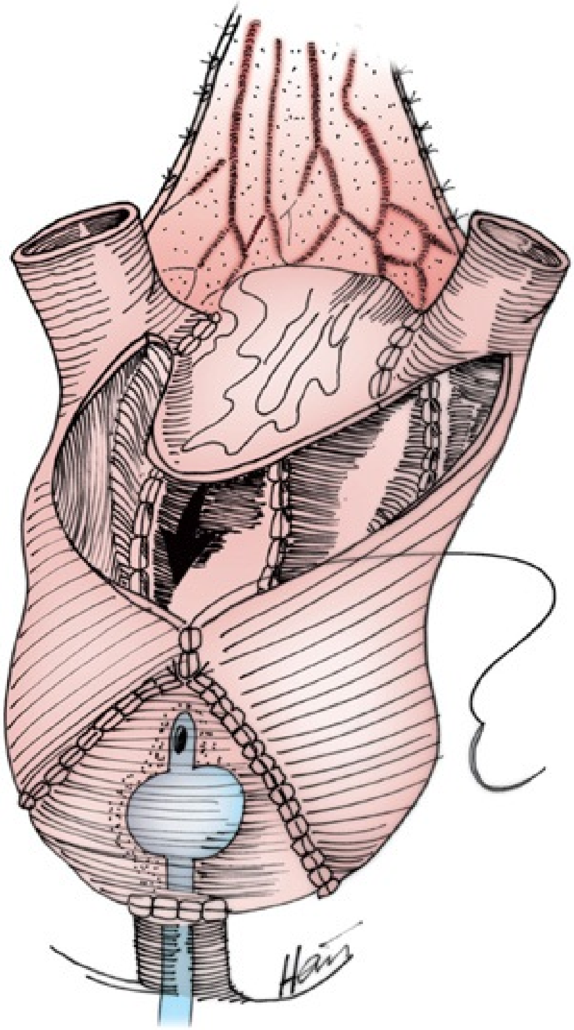

FIGURE 79.17 Closure of reservoir.

In 10% of patients, the ileourethral anastomosis may cause some difficulties. All gauzes, laps, and towels are removed, and gentle traction on the mesoileum is exerted with both hands (one behind and the other ventral to the ileal plate) to guide the neobladder down to the pelvic floor. Some or all of the following tricks are helpful (Fig. 79.18): loosening the retractor, straightening the operating table, removing the sacral cushion, neutralizing the extended position of the patient, bringing up the perineum with a sponge stick, freeing the cecum and descending colon as in retroperitoneal lymph node dissection (RPLND), moving up the neobladder outlet to the tip of the U-shaped flap, or performing an end-to-end anastomosis after tubularization of the U-shaped flap (Fig. 79.19). However, this should be done only as a “last resort” to reach the pelvic floor, if everything else fails. Any incisions into the mesentery of the neobladder should be avoided. The neobladder mesentery should not be pulled roughly to the pelvic floor.

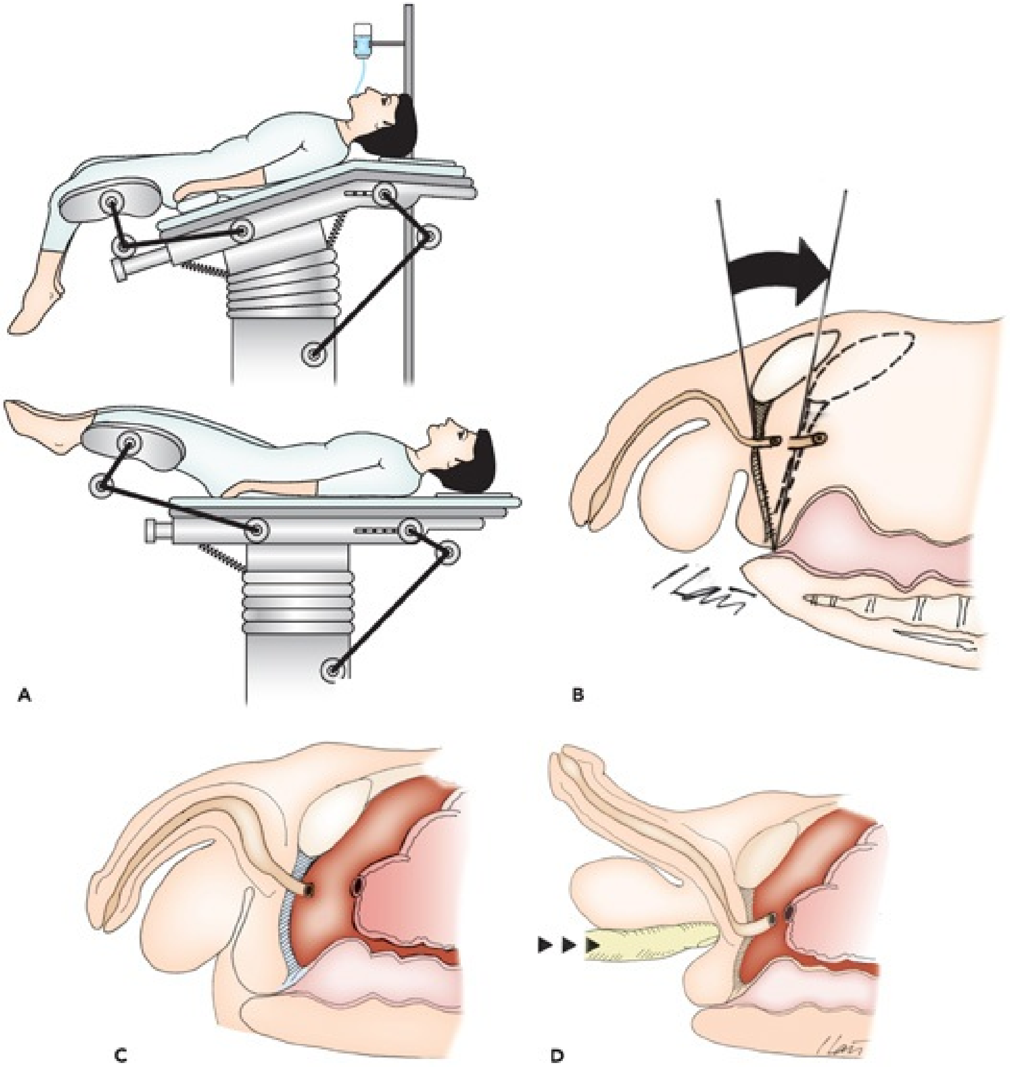

FIGURE 79.18 Methods to get the neobladder to the pelvic floor. A and B: Changing the extended position of the patient to slightly supine and removing the sacral cushion rotate the pelvic floor upward. C and D: Pushing up the perineum with a sponge stick or finger approximates the urethral remnant and neobladder.

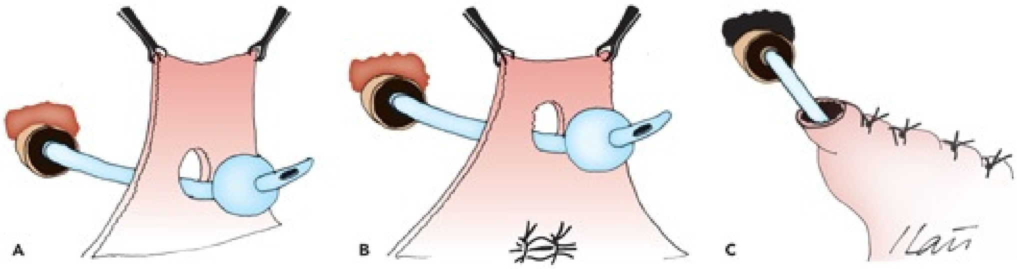

FIGURE 79.19 A–C: Moving the neobladder outlet closer to the tip of the U-shaped flap of ileal plate. If this still does not allow tension-free anastomosis, one should tubularize the U-shaped flap and perform direct (end-to-end) anastomosis.

Ileoureteral Anastomosis

Since 1996, we have been using a freely refluxing, open, end-to-side ureteroileal anastomosis, which is the simplest small-bowel surgery and which has reduced our nontumor related stenosis rate from 16.3% to 5.4%. Further advantages of this chimney modification are the extra length to reach the ureteral stump, the ease of surgery far outside the pelvic cavity, a tension-free anastomosis, no risk of ureteral angulation with neobladder filling, and a simplified flank access for revisional surgery (8–11).

On each side, the ureters are trimmed as appropriate for their chimney (Fig. 79.20). The ureterointestinal anastomosis can be done extraperitoneally above the common iliac vessels using a Bricker or Wallace (our choice) technique without competing with the bowel mesentery for an anastomotic site (see Fig. 79.20). After appropriate ureteral stents are placed, they are brought through the anterior neobladder suture line. The remaining anterior neobladder wall is closed in a T shape with running 3-0 SASs. No cystostomy tube is placed. Two 20Fr silicone drains are placed into the small pelvis.

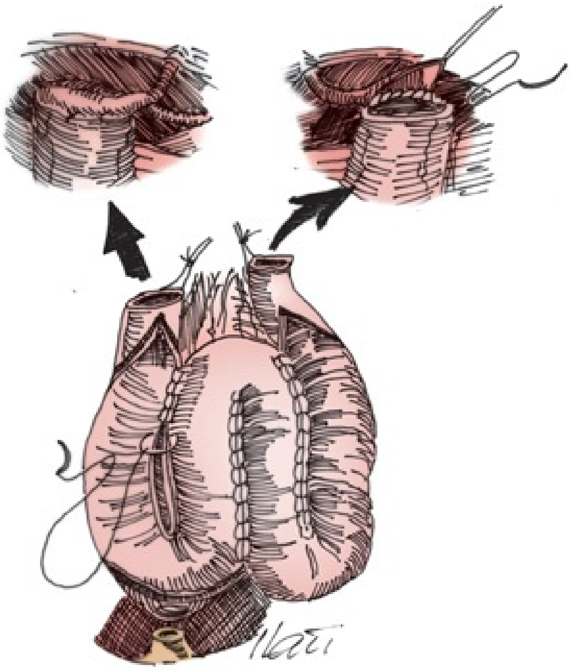

FIGURE 79.20 Refluxing ileoureteral anastomosis using chimneys of a 3- to 5-cm afferent limb on each side.

Using the two large peritoneal flaps from the visceral pelvic peritoneum, this goal can easily be reached (see Fig. 79.1). Both flaps are sewn together, except for the portion where the mesentery of the neobladder runs through them. The peritoneal cavity is closed in a standard fashion (Fig. 79.21). Alternatively, the flaps can be sewn to the posterior wall of the neobladder.

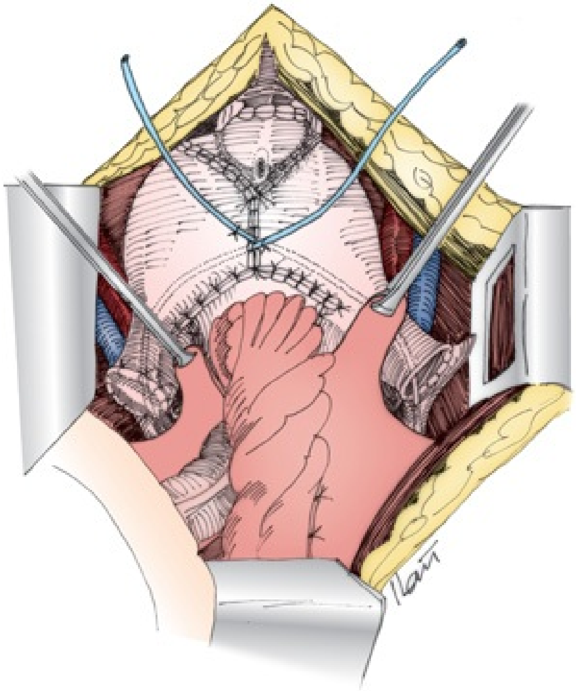

FIGURE 79.21 Completely extraperitoneal localization of the neobladder as well as ileourethral and ileoureteral anastomoses.

Excessive mucus production of the ileal bladder may rarely cause a problem by obstructing the urethral catheter in the postoperative course. Therefore, the ileal bladder is rinsed via the cystostomy with 50 to 100 mL of saline twice a day, starting on postoperative day 5. Routinely, the ureteral stents are removed between postoperative days 7 and 14.

As soon as the urine is in contact with the ileal bladder mucosa, reabsorption of urine electrolytes may occur. Therefore, the base excess is checked at weekly intervals for the first 4 weeks and monthly thereafter. Approximately 50% of all patients need temporary alkalinizing therapy.

The urethral catheter is removed between postoperative days 14 and 21, after a cystogram has demonstrated complete healing of the ileourethral anastomosis. Rarely, there is still leakage from the anastomosis. When this is occurs, it is treated by prolonged catheter drainage until the leak has closed spontaneously.

OUTCOMES

Complications

The complications of orthotopic bladder substitutes in the hands of the most experienced surgeons have been considered in detail (4,8–11). We believe that the morbidity of orthotopic bladder substitutes is actually similar to, or lower than, the true rates of morbidity after conduit formation, contrary to the popular view that conduits are simple and safe.

There are several new complications unknown during the conduit era, including incisional hernias, as a consequence of the Valsalva maneuver: neobladder-intestinal and neobladder-cutaneous fistulas, mucus formation, and neobladder rupture. The secretion of mucus can be dramatically increased.

Spontaneous late rupture of neobladders is a rare but potentially life-threatening complication. In the majority of cases, it is secondary to acute or chronic overdistention and bacterial infection. Other factors are minor blunt abdominal trauma or urethral occlusion. Chronic ischemic changes of the neobladder’s wall, possibly facilitated by detubularization and the variability of the mesenteric circulation, are additional factors that lead to perforation. The rupture site is typically the upper part of the right side of the reservoir. This is the most mobile part of the reservoir and undergoes the most marked distention during overfilling, which may constitute an additional factor for perforation in this location. There is no reliable procedure to establish the diagnosis. Cystography is misleading in three of four patients with neobladder rupture. A high index of suspicion and early aggressive operative treatment in patients suspected of having a neobladder rupture are instrumental in providing a successful outcome. Prevention of neobladder rupture comprises careful monitoring of neobladder emptying. Physicians must be aware of the risk of rupture. Patients must be encouraged to void regularly, especially at bedtime, and perform clean intermittent self-catheterization to avoid chronic reservoir overdistention. In the event of anesthesia, proper bladder drainage should be performed.

Results

In some studies, perioperative death occurred in 3% of patients. Neobladder-related early and late complications occurred in 15% and 23% of patients, respectively. Neobladder-related early and late abdominal reoperation rates were 0.3% and 4%, respectively. Perioperative neobladder-unrelated early complications were observed in 33%, and 12% of patients required operative treatment. Late postoperative complications unrelated to the neobladder occurred in 12% of patients, and 5%

required open surgical revision. Ninety-six percent of male patients voided spontaneously, 4% performed clean intermittent catheterization in some form, and 1.7% performed regular intermittent catheterization. Thirty percent to 40% of women required some form of intermittent catheterization to completely empty their neobladder (7,9). Daytime and nighttime continence was reported as good by 96% and satisfactory by 95% of patients. Unacceptable daytime continence requiring more than one pad per day occurred in only 4% of patients, and only 5% were wetting more than one pad per night.

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CHAPTER 80 COLONIC ORTHOTOPIC BLADDER SUBSTITUTION

JOACHIM W. THÜROFF AND LUDGER FRANZARING

Orthotopic bladder substitution can be realized from ileum only or from colonic segments either alone (1,2) or in combination with small bowel segments as a composite reservoir (3–8). The rationale of using large bowel for urinary diversion is based on anatomic and functional considerations. Surgical creation of a urinary reservoir from bowel segments generally means transformation of a cylinder into a sphere (9). The length of bowel to be excluded from the intestinal tract for formation of a reservoir of a given capacity depends on the diameter of bowel used to create the reservoir. In the volume formula of a cylinder ($V = \pi r^2 \cdot l$), the radius determines the volume by its second power; hence, the larger the bowel diameter, the less proportional bowel length is required. Thus, large bowel with its greater diameter can contribute significant capacity to a continent reservoir despite only a shorter segment having to be excluded from bowel continuity.

Physiologically, fat-soluble vitamins (A, D, E, K) and water-soluble vitamins B_{12} and folic acid as well as biliary acids are all absorbed from the entire ileum but not from colon. Consequently, possible malabsorption syndromes are related only to resection of ileum but not to colon resection. The critical length of ileum resection is about 60 cm above, which the risk of secondary malabsorption syndromes starts to increase. These facts should influence choice of bowel segments for reservoir formation in favor of reducing the length of ileum segments for a composite reservoir or of avoiding ileum entirely in an all-colon reservoir (10–12).

However, the large bowel is less distensible than small bowel (13). Although at first, this may be regarded as a disadvantage, it may be advantageous, specifically for spontaneous voiding from an orthotopic bladder substitute in the long run. Intestinal urinary reservoirs start their life at a surgically determined volume that increases over time by gradual distention. During this process, large bowel segments have the advantage that the longitudinal arrangement of taeniae prevents the development of a decompensated substitute megacystis as has been described for ileum reservoirs requiring in up to 60% of females emptying of the orthotopic bladder substitute by intermittent self-catheterization. In addition, large bowel segments, especially cecum and ascending colon, offer several alternatives for safe and effective antirefluxive ureteral implantation.

The downsides of using large bowel for creation of an orthotopic reservoir have to be weighed against the advantages of large capacity, less malabsorption, less overdistention, and reliable antireflux techniques.

First, many urologic surgeons are not familiar with large bowel surgery and feel uncomfortable with it, specifically when performing the bowel anastomosis after resection of the segments for the urinary reservoir. Second, generous mobilization and rotation of segments is required to allow a tension-free transposition as an orthotopic reservoir into the true pelvis. Surgical techniques using large bowel may also be more time-consuming because adhesions with the greater omentum have to be freed.

The different techniques of constructing an orthotopic reservoir, either from large bowel only or in combination with small bowel segments as a composite reservoir, refer to the very same principles of continent urinary diversion: detubularization and spherical reconfiguration (14). Thus, the success of orthotopic bladder substitution is not confined to selection of small bowel segments; good results have been reported with the ileocecal segment, the right colon, and the sigmoid colon. However, the physiology of large bowel segments changes from proximally to distally with decreasing capacity and compliance and increasing wall tension and intraluminal pressures. This translates into higher capacity and lower pressure of the cecum and ascending colon as compared to the descending and sigmoid colon. The surgical technique of the Mainz ileocecal pouch as described in the following in detail (8) may in this context serve as a general example of construction of an ileocolonic composite pouch.

However, one single technique of continent urinary diversion does not fit all patients and all pathologies. Thus, modern concepts of intestinal urinary diversion require surgical versatility for individualization of the surgical technique according to the requirements of the underlying pathology and the wishes of the patient.

DIAGNOSIS

The scope of diagnostic studies is determined by the underlying disease because of which the native bladder has to be substituted. For continent urinary diversion as compared to incontinent diversion, the most important assessment is upper urinary tract morphology and renal function. Grossly dilated upper urinary tracts may not drain as well into a continent urinary reservoir as into an incontinent zero-pressure conduit diversion. Every intestinal urinary reservoir reabsorbs hydrogen and chloride ions. The resulting metabolic acidosis is generally balanced by respiratory compensation and by an increased renal acid secretion. As a consequence, renal reserve must be sufficient as judged by a glomerular filtration rate better than a minimum of 50% of the age-related normal global renal function.

The intestinal tract must be evaluated in order to avoid surgical or postoperative problems. Concerning patient history, special attention must be paid to inflammatory bowel disease, prior abdominal surgery or radiotherapy, and related abnormalities of stool and defecation. When large bowel segments are used for continent diversion, radiographic imaging or colonoscopy is mandatory to exclude asymptomatic tumors of the large bowel.

INDICATIONS FOR SURGERY

The indications for a colonic orthotopic bladder substitute or a composite reservoir of ileum and colon are not different from those for ileal orthotopic bladder substitution (15). However, in patients with neurogenic anal sphincter incompetence, any change in stool consistency secondary to bowel resection bears the risk of worsening a preexisting anal incontinence. Another aspect of all forms of orthotopic bladder substitution, specifically in women, is the risk of urinary retention requiring emptying of the reservoir by intermittent catheterization (16–18). Thus, the willingness and ability to perform intermittent self-catheterization have to be determined and possibly practiced preoperatively. This is of special importance in women, patients with neurogenic bladder, and children (11,12). Generally, children may be able to perform intermittent self-catheterization of the urethra from about 6 years of age.

ALTERNATIVE THERAPY

Alternatives to orthotopic bladder substitution with colonic segments are orthotopic ileal neobladders (15). Alternatives to continent orthotopic bladder substitution are continent cutaneous urinary diversion (e.g., Mainz Pouch I, Indiana Pouch) or continent anal urinary diversion (Mainz Pouch II). Alternatives to continent urinary diversion are incontinent conduit diversions (ileal conduit, sigmoid conduit, transverse colonic conduit).

SURGICAL TECHNIQUE

The day before surgery, the bowel is cleansed by oral administration of 3 L of polyethylene glycol. Perioperative parenteral antibiotic therapy with broad-spectrum antibiotics should include antianaerobic activity (e.g., ampicillin/clavulanic acid and metronidazole). The antibiotics are administered 1 hour before surgery and continued until the fifth to seventh postoperative day.

The patient is positioned supine on the operating table. Radical cystoprostatectomy should adhere to the same principles as radical prostatectomy: that is, to preserve maximum urethral length and, if possible and indicated, to preserve the neurovascular bundles (19,20).

For ileocecal orthotopic bladder substitution (8), the cecum and ascending colon are mobilized beyond the right colonic flexure. Extended mobilization is helpful for easy transposition of the pouch into the small pelvis.

The terminal 30 cm of ileum and 10 cm of cecum and ascending colon are isolated from bowel continuity. The 10 cm of prevalvular ileum and the ileocecal valve will not be opened antimesenterically because the prevalvular ileum will be used for ureter implantation with the ileocecal valve as antireflux mechanism. If the ureters have to be resected short, for example, because of tumor extension/dysplasia or because of radiation damage, a longer segment of prevalvular ileum may be used as ileal substitute for both ureters (see Fig. 80.1 N and O). However, this requires accordingly longer segments of ileum, specifically prevalvular ileum, to be excluded from bowel continuity at this stage.

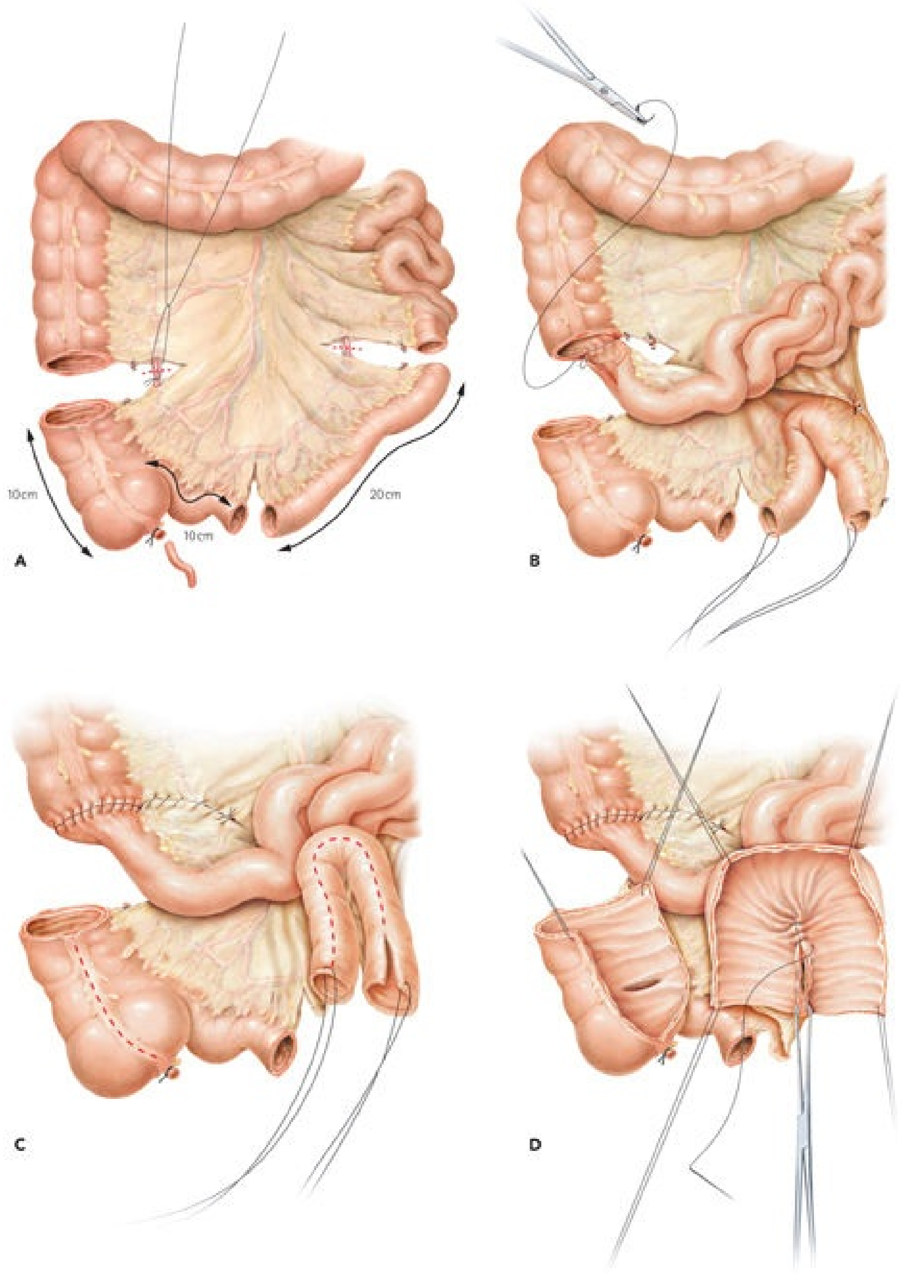

FIGURE 80.1 Construction of the Mainz pouch orthotopic bladder substitution (8). **A:** Isolation of the ileocecal segment consisting of 30 cm of ileum and 10 cm of cecum and ascending colon. Separation of the proximal 20 cm of ileum from the excluded bowel segments. **B:** Spatulated end-to-end ileoascendostomy. **C:** Antimesenteric opening of the proximal 20 cm of ileum as well as of cecum and ascending colon (*broken line*). **D:** Side-to-side anastomoses of ileum in a U-shape configuration. *(continued)*

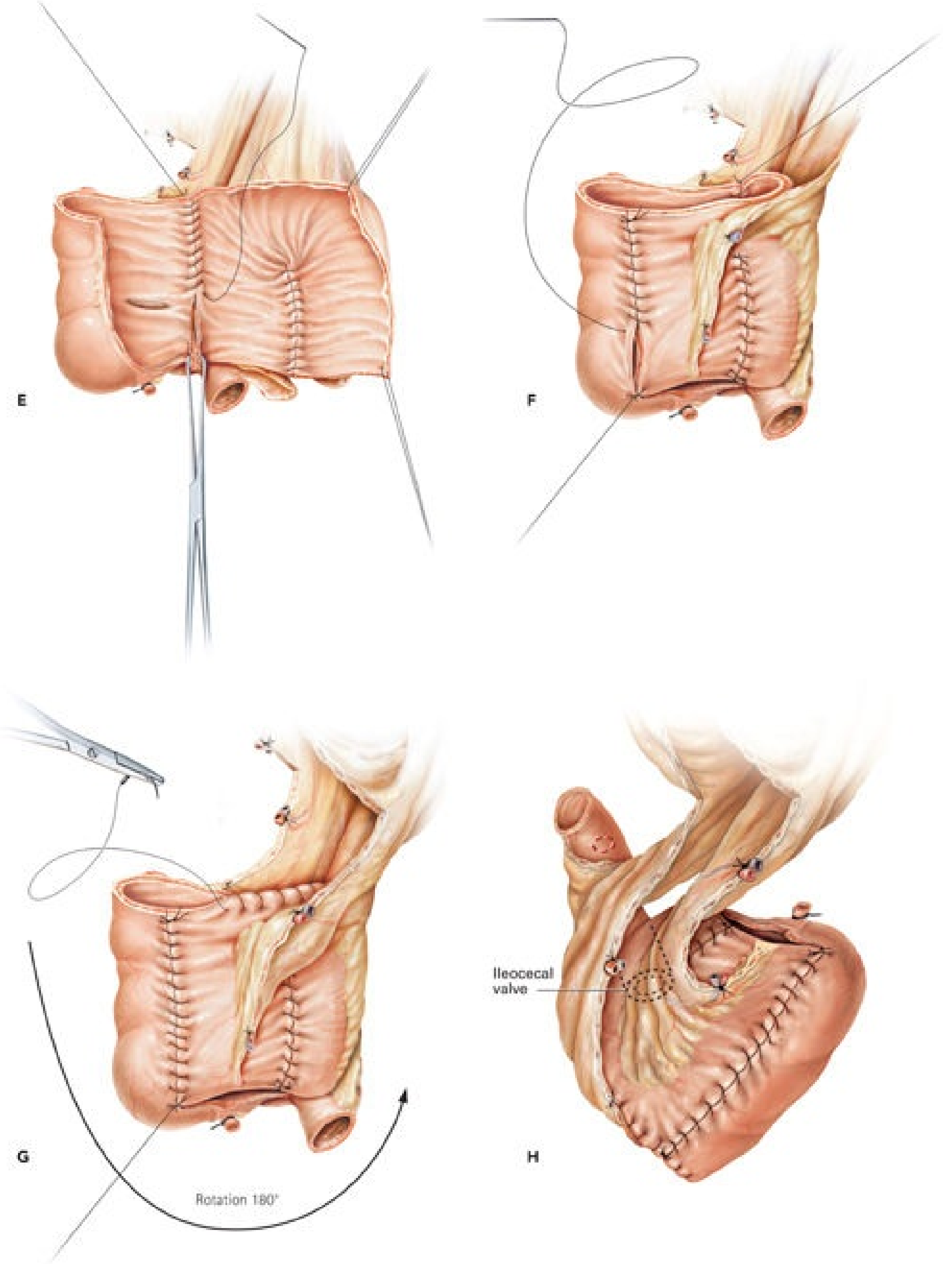

FIGURE 80.1 *(continued)* **E:** Side-to-side anastomosis of ileum with cecum and ascending colon. **F:** Door-wing closure of the anterior pouch wall (side-to-side anastomosis between ileum and colon). **G:** Closure of the upper aspect of the pouch. 180-degree counterclockwise rotation of the pouch with insertion of the ileocecal vessels as axis of rotation. **H:** With the rotation, the prevalvular ileum is transferred posterior to the mesentery of the pouch into a cranial position. *(continued)*

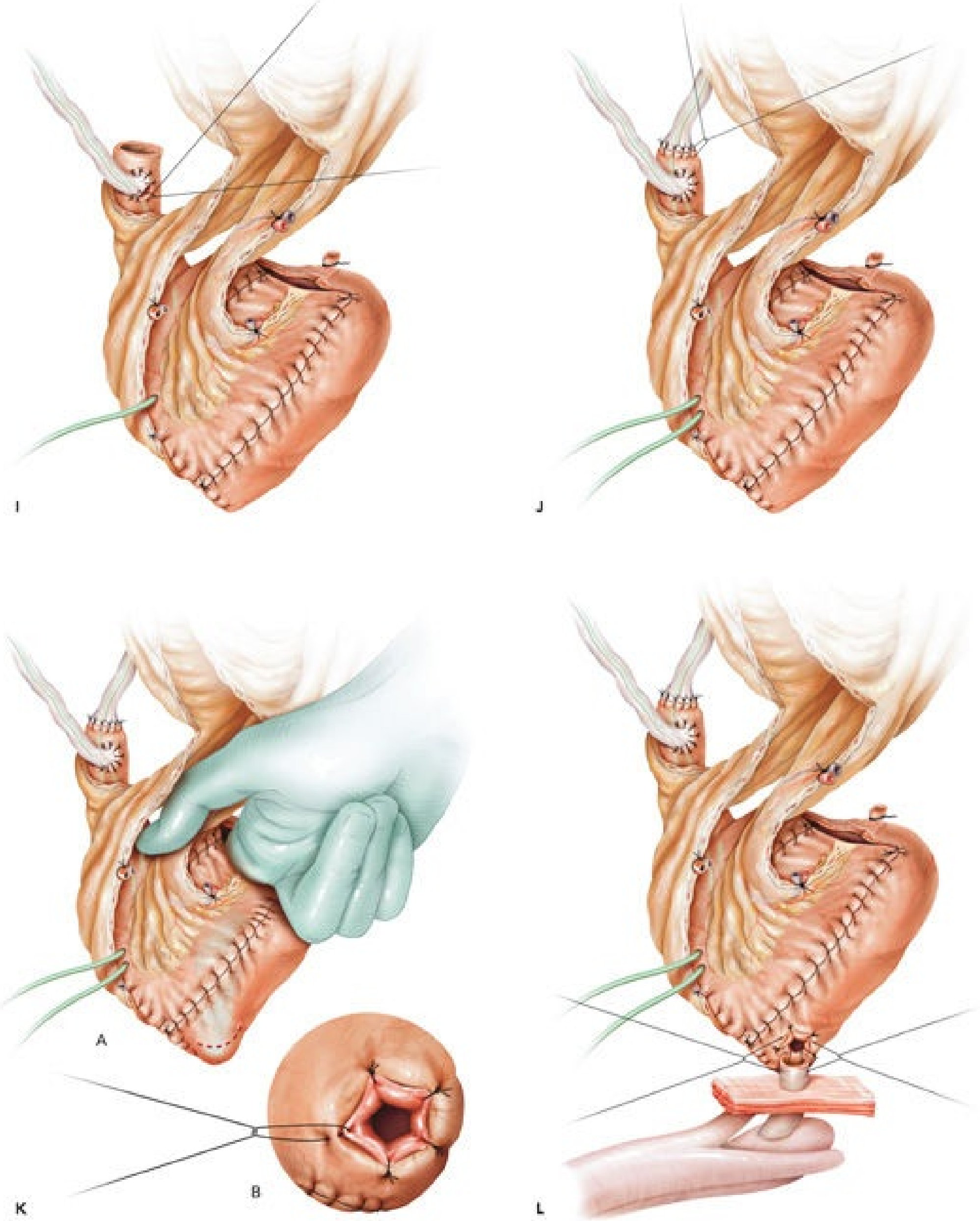

FIGURE 80.1 *(continued)* **I:** End-to-side implantation (Nesbit) of the right ureter into the prevalvular ileum. **J:** Spatulated end-to-end anastomosis (Wallace) of the left ureter into the prevalvular ileum. **K:** Buttonhole incision into the lowest aspect of the pouch (ascending colon) for urethral anastomosis (**A**). Eversion of the intestinal mucosa (**B**). **L:** Completion of the urethral anastomosis with eight interrupted sutures. *(continued)*

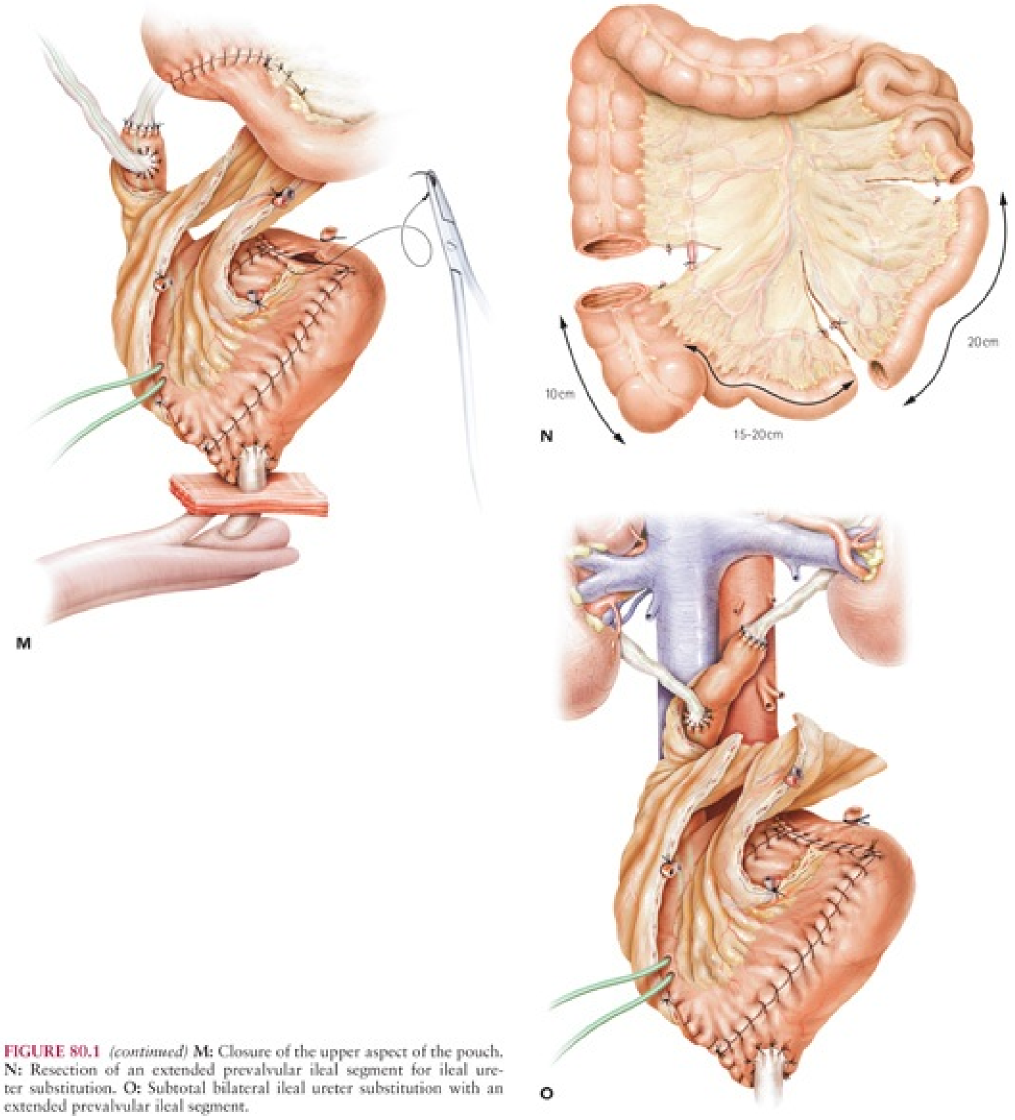

FIGURE 80.1 *(continued)* M: Closure of the upper aspect of the pouch. N: Resection of an extended prevalvular ileal segment for ileal ureter substitution. O: Subtotal bilateral ileal ureter substitution with an extended prevalvular ileal segment.

A Foley balloon catheter is proximally inserted into the ileum of the excluded bowel segments, which are irrigated with generous amounts of saline until the irrigation fluid appears clear. Thereafter, the proximal 20 cm of ileum is separated from the terminal 10 cm (or longer for ileal ureter substitution) of prevalvular ileum, with transection of the superficial arcade of the mesentery only. The appendix is resected.

The intestinal continuity is restored by a spatulated end-to-end ileoascendostomy. The single-row seromuscular anastomosis is established with running 4-0 glyconate sutures.

The separated proximal loop of 20 cm ileum as well as cecum and ascending colon are split open at their antimesenteric borders. The posterior wall of the pouch is completed by side-to-side anastomoses of the separated 20 cm of ileum in a U-shaped configuration to each other and with the ascending colon. The anastomoses are performed by single-row, all-layer running sutures of 4-0 polydioxanone on a straight needle. For closure of the anterior wall of the pouch, the bowel segments are opposed to each other in a door-wing fashion. The anterior wall of the pouch is established as side-to-side anastomosis between ileum and colon with single-row, all-layer running 4-0 polydioxanone sutures on a straight needle. The upper aspect of the pouch is closed with single-row, all-layer 4-0 running glyconate sutures; however, the lower aspect remains open at this stage.

The blood supply of ileocecal reservoirs is based on the ileocolic artery, which always allows tension-free anastomosis to the urethra when a 180-degree counterclockwise rotation of the pouch is performed with the insertion of the ileocolic vessels as axis of rotation. This brings the upper aspect of the pouch (ascending colon) to the urethra and the ileocecal region behind the mesentery into a cranial position on the right side. In pure right colonic pouches, with additional blood supply from the right colonic artery, reaching down to the urethral stump may sometimes be more difficult (Fig. 80.2). The blood supply of the sigmoid colon is from the inferior mesenteric and superior rectal arteries (Fig. 80.3). Sigmoid reservoirs thus always easily reach down to the urethral stump (Fig. 80.4).

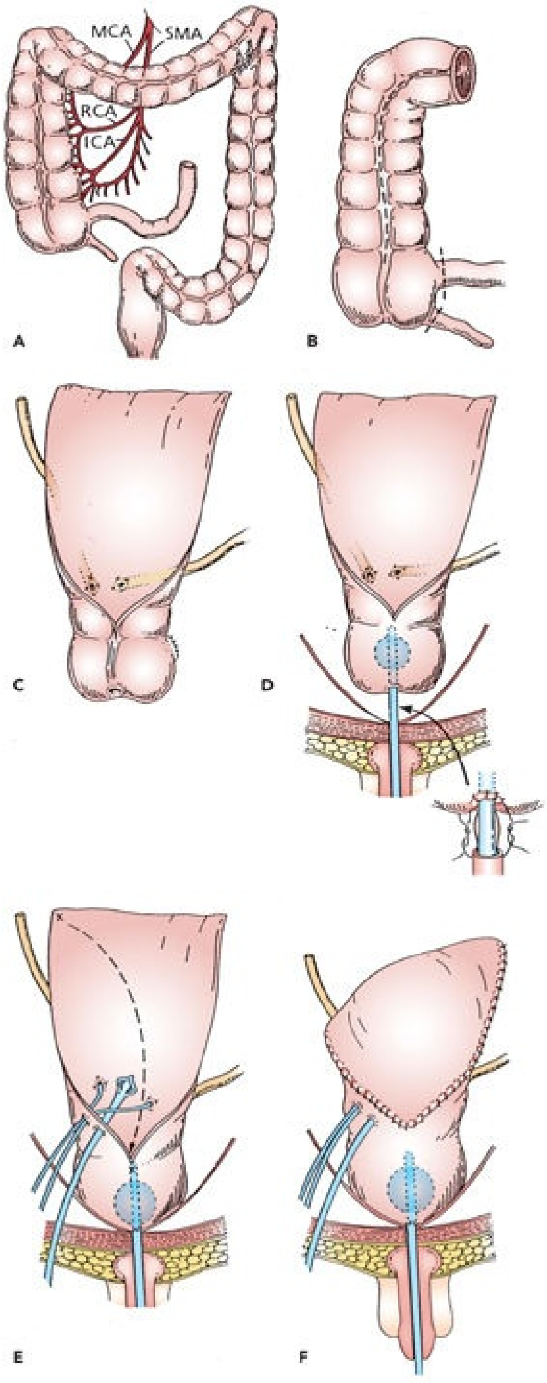

FIGURE 80.2 Construction of a right colonic reservoir (1). **A and B:** Isolation of a colonic segment consisting of cecum, ascending colon, and the right colic flexure. **C and D:** Opening of the segment through the taenia libera, leaving the cecum intact and anastomosing it to the urethra. **E and F:** The ureters are anastomosed into the colonic segment using the "buttonhole" submucosal implantation technique. This technique describes the ureters entering the submucosal tunnel via a buttonhole incision into the posterior wall of the pouch. Reconfiguration is completed by folding the open cranial segment over the caudal segment and anastomosing both lateral margins. *ICA*, ileocecal artery; *MCA*, middle colonic artery; *RCA*, right colonic artery; *SMA*, superior mesenteric artery.

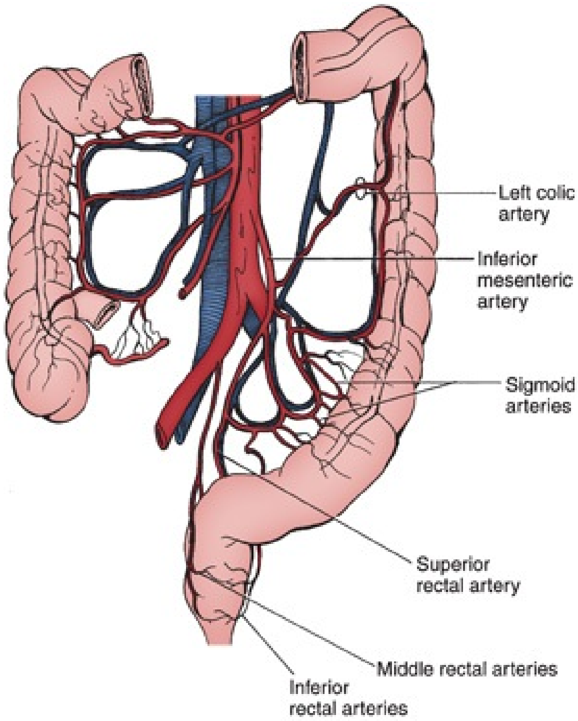

FIGURE 80.3 Vascular supply of the left colon and rectosigmoid.

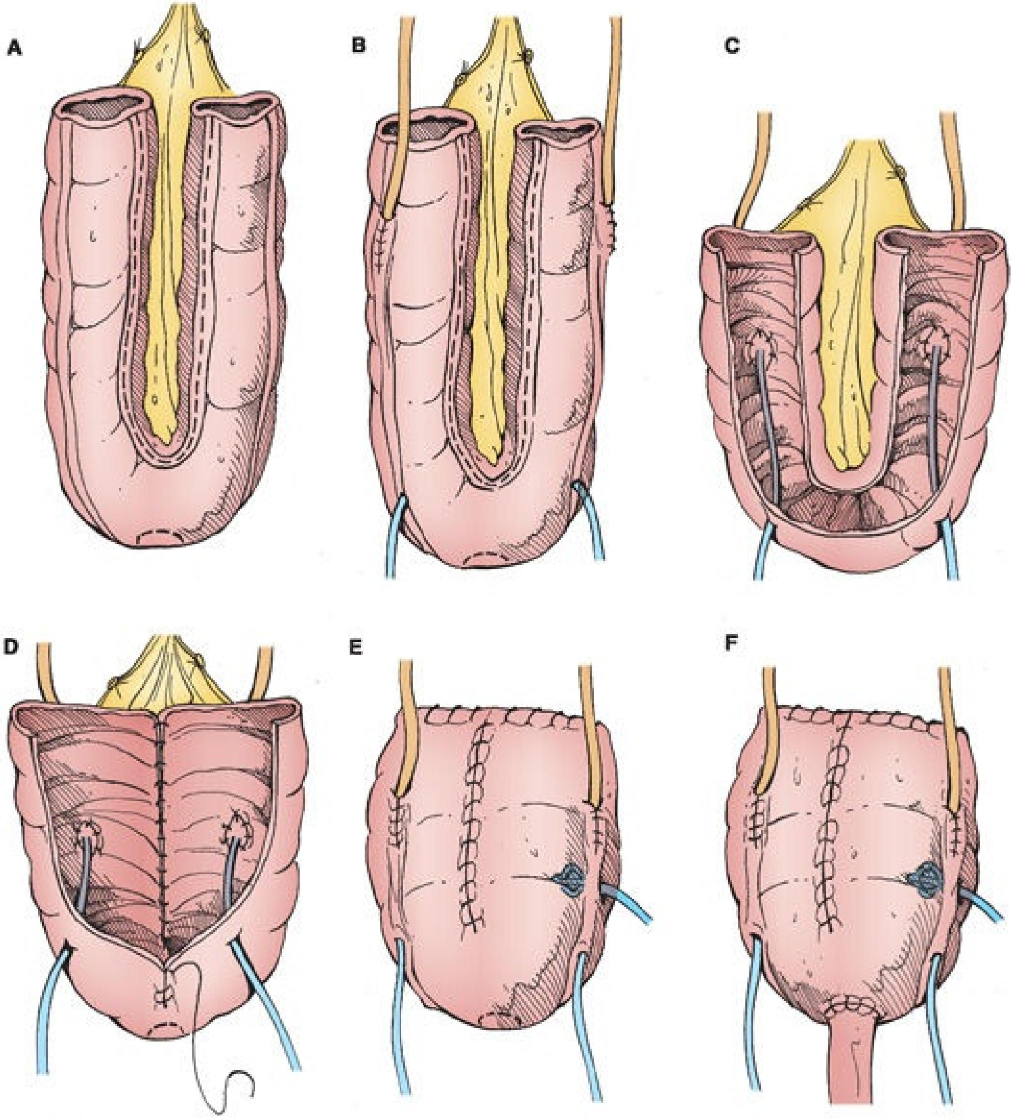

FIGURE 80.4 Construction of a sigmoid colon reservoir (Reddy and Lange) (2). **A:** Isolating a segment of about 30 cm of sigmoid colon. **B:** Submucosal tunnel ureteral implantation. **C and D:** Detubularization, U-shaped reconfiguration of the segment, and side-to-side anastomosis of the back wall of the pouch. **E and F:** Completion of the anterior wall of the pouch and anastomosis to the urethra.

Ureteral Implantation

A variety of techniques reflects the surgical challenge to create an antireflux mechanism without obstruction of the ureter. This challenge may be increased by a number of pathologic conditions in the individual patient. Ureters may be dilated, fibrotic, or ischemic secondary to obstruction, previous surgery, or radiotherapy. Bowel segments may be altered from inflammation, dilatation, or ischemia secondary to inflammatory bowel disease, previous surgery, or radiotherapy. Mechanical factors (e.g., position changes of the reservoir) or biochemical factors (e.g., effects of urine on the ureteral adventitia or on the intestinal mucosa) may have long-term effects on the whole system.

The rationale of implanting the ureters by an antirefluxive technique into an orthotopic bladder substitute is to protect the upper urinary tracts from retrogradely transmitted pressure peaks and from ascending bacteriuria. However, the standard technique of antirefluxive ureteral implantation into large bowel was conceived from ureterosigmoidostomy, which means diverting urine into a high-pressure reservoir containing feces and urine. The necessity of antirefluxive ureteral implantation into orthotopic low-pressure reservoirs is questioned because they provide a pop-off mechanism when overfilled—unlike most forms of continent cutaneous diversion—by transurethral urinary leakage. Another argument is a supposedly lower bacterial contamination rate as compared to continent cutaneous reservoirs that require intermittent catheterization. Nevertheless, protection from poucho-renal reflux remains an advantage, if it can be achieved without an additional risk of introducing ureteral anastomotic obstruction by the surgical technique. A variety of different antireflux mechanisms have been described, which may be classified into two general types. In one type, the ureter itself is part of the antireflux mechanism, whereas in the other type a bowel-derived antireflux mechanism is interposed between ureters and reservoir.

In any case, for implantation of the ureters into cecum or ascending colon, the left ureter has to be rerouted into the right retroperitoneum preferably above the inferior mesenteric artery as for ileal conduit diversion.

Antirefluxive ureteral implantation techniques, in which the ureter becomes part of the antireflux mechanism, mostly follow the “flap-valve” principle: An oblique entry of the ureter into the reservoir is created with a submucosal “tunnel” course that allows transmission of the reservoir pressure onto the ureter and against the seromuscular layer of the reservoir. This pressure transmission passively compresses the ureter with rising reservoir pressures. The most frequently used principles to transmit the reservoir pressure to the ureter are the submucosal tunnel technique and the seromuscular extramural tunnel technique.

In the submucosal tunnel technique (1,2,7,11,12), both ureters are implanted into the colon with a 2- to 3-cm submucosal tunnel. Ureters are anchored with 6-0 glyconate sutures to the muscularis of the bowel wall, and the neo-orifices are established by 6-0 glyconate or 7-0 polyglycolic acid ureteromucosal sutures.

In the orthotopic Mainz pouch, protection from reflux between the urinary reservoir and the kidneys is provided by the antireflux function of the ileocecal valve (3,8). The cecum with the ileocecal valve is incorporated into the pouch, and the right ureter is anastomosed in an end-to-side technique (Nesbit) and the left ureter in a spatulated end-to-end technique (Wallace) into the terminal prevalvular ileum. Thus, the flow of urine is directed from the ureters into the pouch through the ileocecal valve. Separate implantation of the ureters into the prevalvular ileum has the advantage over common Wallace-plate implantation, that surgical revision of a single ureter, for example, because of obstruction or ureteral tumor recurrence is possible without dealing with the other ureter.

The ureters are stented with 6Fr or 8Fr stents, which are routed through the ileocecal valve and brought out through the reservoir wall. For pouch drainage, a 10Fr pouchostomy pigtail catheter is placed into the reservoir. The anastomosis of the pouch with the urethra is performed at the lowest aspect of the pouch as determined with an into the pouch inserted finger. Generally, this is a colonic segment (ascending colon), into which on the inserted finger a 3-mm transverse incision is performed. The mucosa is everted with several 4-0 polyglytone rapidly absorbable monofilament sutures. A 20Fr Foley balloon catheter is inserted transurethrally into the reservoir. The urethral anastomosis is completed using the eight 4-0 glyconate monofilament double armed sutures with two 5/8 needles (FR26), which had been previously at the stage of cystectomy placed through the urethral stump. Closure of the upper aspect of the pouch is completed in the same way as described previously. A 20Fr gravity drain is placed each into the small pelvis and at the ureteral implantation site.

Ureteral stents are removed at day 10 and 11. The transurethral catheter is removed at day 12 when a pouchogram has ruled out extravasation. Residual urine is checked via the pouchostomy catheter when the patient voids spontaneously. The pouchostomy catheter is removed at residual urine volumes <50 mL. In neurogenic cases, patients are instructed in intermittent catheterization.

OUTCOMES

Complications

In the early postoperative months, nonperistaltic contractions of the bowel segments of a Mainz pouch do occur but subside spontaneously with increasing capacity of the pouch. In case of persistent inadequate compliance or persistent contractions of the pouch, antimuscarinics may be used for pharmacotherapy.

About 60% of patients postoperatively have an asymptomatic metabolic acidosis, which can be diagnosed by venous blood gas analysis and should be prophylactically balanced at a base excess below −2.5 by oral alkali substitution (sodium/potassium citrate/bicarbonate) (10).

The risk of secondary malignancies is low, albeit higher than in ileal neobladders (21,22). Follow-up examinations must include renal ultrasound and/or intravenous pyelogram, blood gases, and, starting from the fifth postoperative year, pouchoscopy and evaluation of serum cobalamin (10,12).

Results

In general, the outcome criteria for orthotopic bladder substitution with intestine are (a) function and morphology of the upper urinary tracts, (b) urinary frequency during day and night, (c) continence during day and night, and (d) ability to void spontaneously. However, one has to keep in mind, that especially continence and the ability for spontaneous micturition may significantly be influenced by the type and quality of surgery preceding the orthotopic substitution itself. Related factors are, for example, preparation of the bladder neck and urethra, sparing of the autonomous nerves (19,20,23), and measures to prevent posterior pouch displacement or pouch-urethral kinking, specifically in females (16). Therefore, functional results attributed to specific kinds of reservoirs actually rely on more factors than the segment(s) of intestine chosen. For ileocecal reservoirs with submucosal tunnel implantation of ureters, a ureterointestinal obstruction rate of up to 7% is reported (24). Continence rates for ileocecal reservoirs vary between 75% and 88% during the day and 67% during the night (4,25). Continence rates for sigmoid colon reservoirs are significantly lower (25).

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CHAPTER 81 CONTINENT CATHETERIZABLE RESERVOIR MADE FROM ILEUM

HASSAN ABOL-ENEIN AND MOHAMED A. GHONEIM

A substantial number of techniques have been described for the creation of continent cutaneous urinary reservoirs. For construction of such systems, three elements are required: a low-pressure compliant reservoir, an antirefluxive ureterointestinal anastomosis, and a continent stoma that allows easy catheterization.

To create a reservoir with high capacity at low pressure, various segments of bowel have been utilized: the ileum, the ileocolonic region, the ascending colon, and the transverse colon. Regardless of the selected bowel segment, detubularization and double folding are basic prerequisites to achieve this goal.

A reliable antirefluxive ureterointestinal anastomosis is necessary, since bacteriuria is a constant feature in these systems and results from intermittent catheterization. The technique employed should provide a unidirectional but nonobstructed flow. The antirefluxing mechanism should not be at the expense of a higher incidence of obstructive complications.

Hinman (1) classified continent outlets into four categories according to the mechanism of their action. These included an antiperistaltic ileal segment (2); imbricated or tapered ileal segments resulting in passive tubular resistance (3); outlets using the pressure equilibration principle, including an ileal spout valve (4), flutter valve (5), inkwell hydraulic valve, intussusception nipple (6), or ileal servomechanism sphincter (7); and flap valves, which are created by the incorporation of tubular structures within the wall of the reservoir, such as the appendix (8), fallopian tubes (9), parts of ileum (10), or tubularized cecal segments (11). Multiplicity of techniques implies that none is optimal. Many of the previously mentioned techniques rely on an inert or even unphysiologic mechanism, and problems and malfunctions soon appear.

In our proposed technique, we have utilized the ileum for construction of the low-pressure reservoir and a serous-lined tunnel to provide an antirefluxive mechanism (12) as well as to create a reliable continent outlet (13).

INDICATIONS FOR SURGERY

Any patient who requires bladder replacement is a potential candidate for this operation. The indications of continent cutaneous urinary diversion include the following:

1. Pelvic malignancies: in patients for whom cystectomy is indicated for bladder cancer or those requiring an anterior pelvic exenteration for other pelvic malignancies
2. Benign indications: These include neuropathic bladders when conservative measures fail, extensive urethral strictures with damaged urethral sphincter, contracted bladders with compromised urinary continence, complex urinary fistulas affecting the sphincteric mechanism, and some cases of bladder exstrophy with failed attempts of primary repair.
3. Urinary conversion: conversion from other types of urinary diversion, such as ileal conduits in young healthy patients, for patients who develop isolated urethral recurrence following radical cystectomy and orthotopic bladder substitution, and in some cases of ureterosigmoidostomy suffering from intractable metabolic acidosis

PATIENT SELECTION AND EVALUATION

Suitable candidates should have reasonable manual dexterity. Motivation to carry out clean intermittent catheterization at regular intervals is necessary. Furthermore, a good prognosis might be expected if the indication to diversion was a pelvic malignancy. Patients who are unfit for prolonged surgery and those with a history of previous bowel resection, short bowel syndrome, or heavily irradiated bowel are among the contraindications for this procedure. Patients with impaired renal function (serum creatinine equal to or >1.8 mg per dL and/or creatinine clearance equal to or <40 mL per minute) are unsuitable candidates since metabolic acidosis would be inevitable.

ALTERNATIVE THERAPY

Alternative techniques of urinary diversion should be discussed with the patient when orthotopic bladder substitution or continent cutaneous reservoirs are contraindicated or unfeasible. These include conduit diversion and anal sphincter–controlled bladder substitutes. The potential postoperative complications, changes in future lifestyle, and long-term sequelae should be clearly explained to the patients.

SURGICAL TECHNIQUE

Preoperative Preparation

Since the small bowel is utilized, no specific preparation is necessary. The only requirement is fasting overnight with administration of intravenous fluids to ensure good hydration. Patients with histories of thromboembolic disease or varicose veins should receive a prophylactic dose of heparin (5,000 U subcutaneously) the night before the operation and every 12 hours thereafter until ambulation. Compression leg stockings are also advised. Although the intention is to use a concealed umbilical stoma, a stoma therapist should examine the patient and determine a suitable site for an abdominal stoma. A parenteral broad-spectrum antibiotic is given just before induction of anesthesia and continued postoperatively for 3 days.

Operative Technique

The patient is put in the supine position with a Trendelenburg tilt. Slight flexion of the knees will further help in the relaxation of the abdominal muscles, facilitate retraction, and provide wider exposure. If total urethrectomy is planned, the patient is put in a slight lithotomy position for access to the perineum. The surgical area to be sterilized and draped extends from the lower chest down to the upper thighs.

A midline incision from the pubis inferiorly to a point halfway between the umbilicus and xiphoid process of the sternum superiorly is generally employed. The incision is encircling the umbilicus by 2 to 3 cm to the left.

The bowel is examined, and a 60-cm long segment of the terminal ileum is isolated. Backlight transillumination of the mesenteric attachment greatly helps the identification of the arterial arcades supplying the selected segments. The bowel is divided 15 to 20 cm proximal to the cecum in the avascular window of Treves between the ileocolic artery and the terminal branch of the superior mesenteric artery. The ileum is divided proximally in a suitable avascular plane between the superior mesenteric arcades. Continuity of the bowel is reestablished by end-to-end anastomosis. The use of an automatic stapler or a hand-sewn technique is a matter of surgeon's preference. The isolated bowel segment is subsequently subdivided into three parts. The middle 40-cm segment is used for construction of the reservoir, the 10-cm oral segment is used for creation of the antireflux mechanism, and the distal 10-cm caudal segment is used for creation of the outlet valve (Fig. 81.1). Great attention is paid to preserving an adequate blood supply for the oral and caudal small bowel segments.

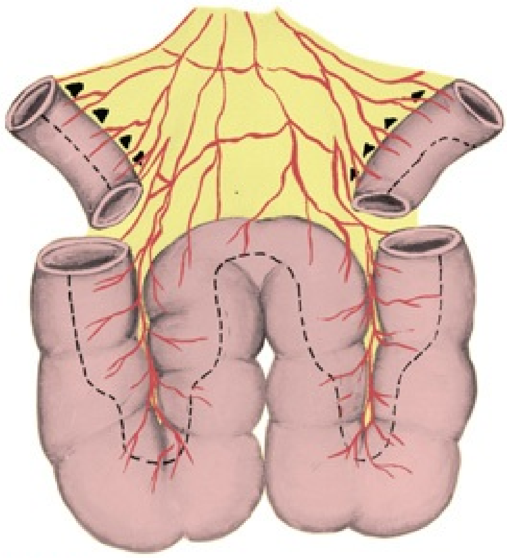

FIGURE 81.1 A 60-cm long ileal segment is isolated; the 40-cm middle segment is arranged in a W configuration and used for construction of the body of the reservoir, the 10-cm oral segment is used for the antireflux mechanism, and the caudal segment is used for the outlet valve.

The middle segment is arranged in a W configuration, and its antimesenteric border is incised by a diathermy knife. The edges of the two medial flaps are joined by a single layer of continuous 3-0 polyglactin sutures. The two lateral limbs are left to serve as serous-lined troughs. The oral and caudal short segments are tapered around a 22Fr catheter. Bowel tapering could be performed either by simple excision and hand-sewn technique or by using a one-step technique with an automatic gastrointestinal stapler. The proximal one-third of the inlet segment is kept untapered for ureteral anastomosis. Three to four small mesenteric windows close to the mesenteric border are created in between the arterial arcades supplying these segments. Each mesenteric window is marked by a small strip of rubber vessel loop. This step will facilitate easy passage of sutures through the mesenteric window (Fig. 81.2).

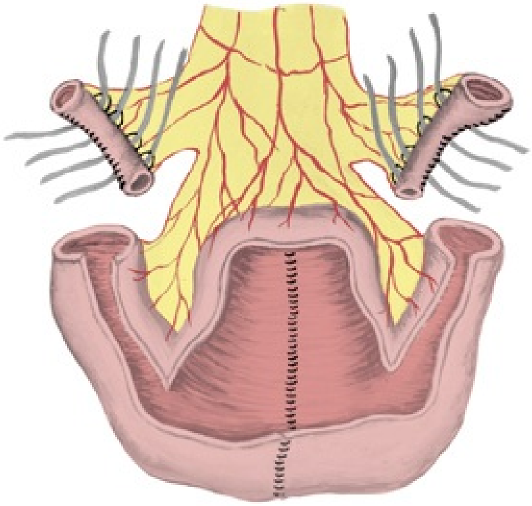

FIGURE 81.2 The bowel segment is incised at the antimesenteric border. The medial flaps are approximated with continuous 3-0 polyglactin sutures. The oral and caudal segments are tapered around a 20Fr catheter. The proximal one-third of the inlet segment is kept untapered. The created mesenteric windows are marked by a strip of vessel loops.

Each tapered segment is inlaid in its corresponding serous-lined trough. The two adjacent limbs of each trough are approximated using 3-0 silk seromuscular suture passing through the mesenteric windows and guided by the inserted strips of vessel loops. The tapered ileal segments are fixed and embedded within the serous-lined extramural troughs. Thus, the bulky mesentery of the embedded segments is excluded behind the pouch (Fig. 81.3). The spatulated distal ends of the tapered segments are anastomosed to the tunnel flaps, and the ileal trough is closed in front of the embedded segment using interrupted 4-0 polyglactin sutures (Fig. 81.4).

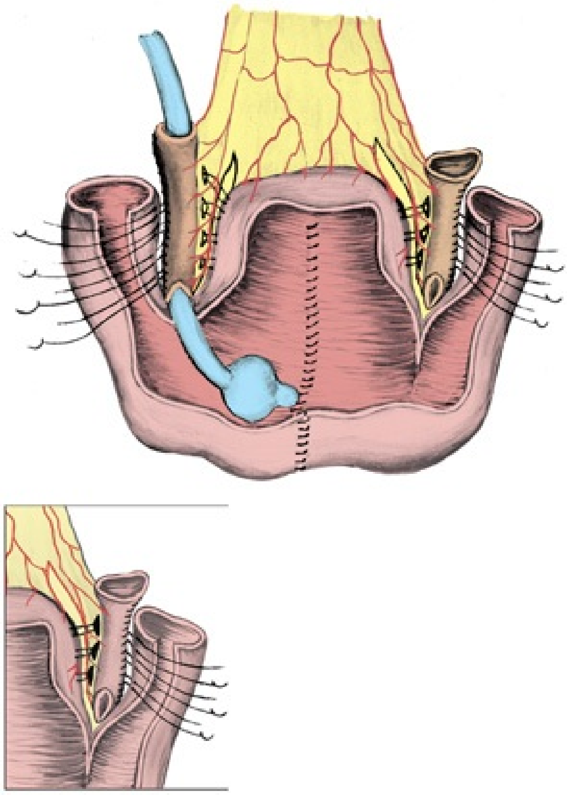

FIGURE 81.3 The tapered ileal segments are fixed and embedded within the serous-lined extramural troughs. The bulky mesentery of the embedded segments is excluded behind the pouch.

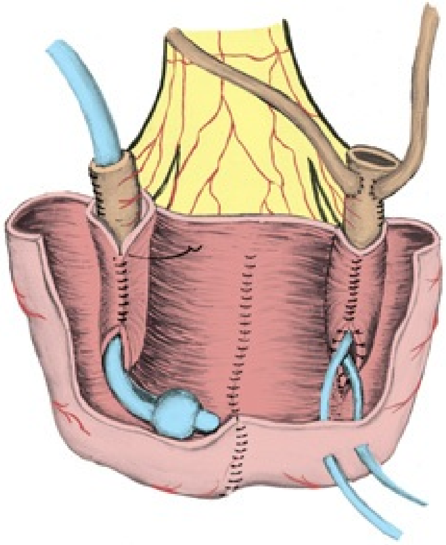

FIGURE 81.4 The spatulated distal ends of the tapered segments are anastomosed to the tunnel flaps, and the ileal trough is closed in front of the embedded segment using interrupted 4-0 polyglactin sutures. Two siliconized stents are threaded through the inlet segment.

Two soft siliconized 8Fr to 10Fr stents are threaded through the inlet segment and secured in place by 4-0 chromic gut sutures. The pouch plate is then closed by approximation of the most lateral ileal flaps anteriorly and to the shoulder flap between the inlet and outlet segments (Fig. 81.5).

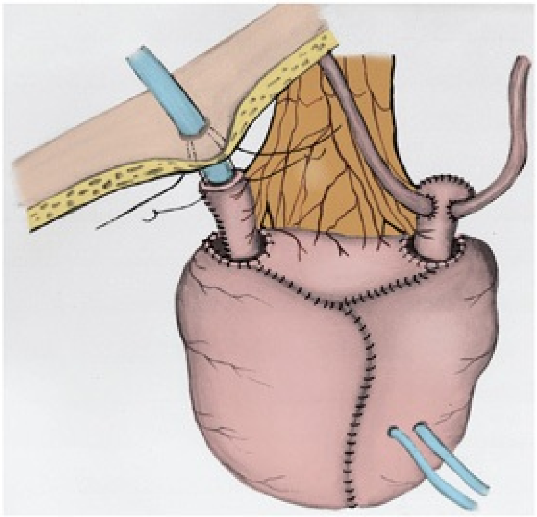

FIGURE 81.5 The pouch plate is closed by approximation of the most lateral ileal flaps anteriorly and to the shoulder flap between the inlet and outlet segments.

The skin of the umbilical funnel is raised and separated from the underlying rectus fascia in the midline. A fascial cruciate incision is made that can admit a 20Fr to 24Fr catheter. The invaginated umbilical skin funnel is identified and a suitable buttonhole is excised. The distal end of the outlet segment is pulled through the rectus fascia aperture. The edge of the intestinal outlet is fixed to the edge of the umbilical skin funnel using interrupted monofilament 4-0 or 3-0 Monocryl sutures including the rectus fascia (Fig. 81.6).

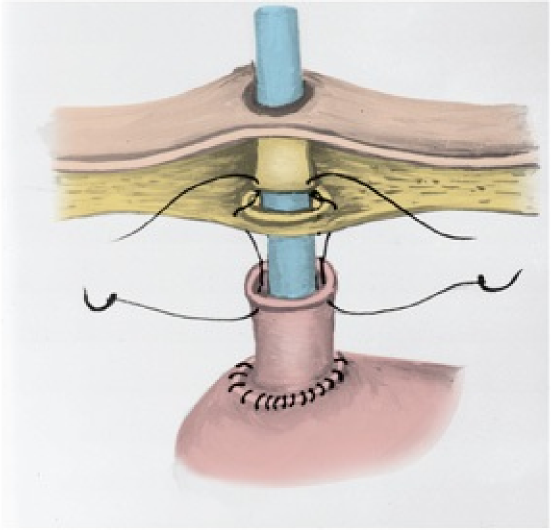

FIGURE 81.6 The edge of the outlet is fixed to the edge of the umbilical skin funnel using interrupted sutures including the rectus fascia.

The body of the reservoir wall around the outlet segment is then fixed to the inner aspect of the abdominal wall. Attention is paid to avoid twisting and/or angulation of the outlet segment. This would avoid difficulties in catheterization later.

The reservoir is drained by an 18Fr to 20Fr Foley balloon siliconized catheter fixed through the stoma.

Both ureters are prepared and oriented toward the inlet segment according to the final position of the pouch. The left ureter is passed from left to right through a high, wide enough mesenteric hole created in the left mesocolon. The right ureter comes from right to left in front of the common iliac artery behind the mesentery of the pouch. Tension-free, widely spatulated, stented implantation of the ureters into the inlet segment is then performed. A Wallace, Nesbit, or end-to-end anastomosis could be utilized according to surgical needs, using 4-0 or 5-0 polyglactin sutures.

The ureteral stents are exteriorized through the anterior wall of the reservoir to which they are secured. This will provide almost a dry reservoir during the healing stage.

The pelvic cavity is drained by two 18Fr fenestrated tubes. Only straight gravity drainage is used. Gastric drainage is established using either a nasogastric tube or open gastrostomy.

An Alternative: Utilization of the Appendix

If the appendix is suitable to serve as an outlet, the ileocecal junction is mobilized sufficiently to ensure a tension-free implantation of the appendix. The appendix is mobilized and detached at its base. The isolated appendix is cut and spatulated at its tip. The lumen is then dilated up to 16Fr to 18Fr using straight dilators. Four windows are created in the mesoappendix. The windows are labeled by rubber vessel loops. The appendix is embedded in the serous-lined trough as described previously (Fig. 81.7).

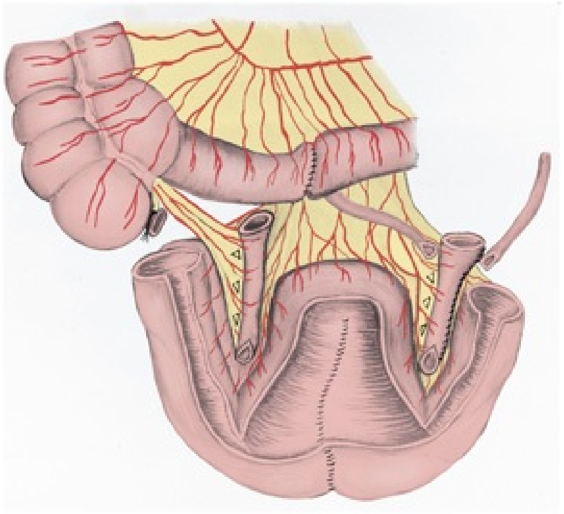

FIGURE 81.7 The appendix is isolated and spatulated at its tip. Four windows are created at the mesoappendix. The appendix is fixed and embedded in the serous-lined trough as previously described.

POSTOPERATIVE CARE

Parenteral fluids are maintained until bowel habit resumes. Prophylactic antibiotics are given routinely for 5 days. Low-molecular-weight heparin is given for 10 days. The draining tubes are removed when the drainage ceases. The reservoir is irrigated with 30 to 60 mL of normal saline every 8 hours to prevent mucus retention. The ureteric stents are removed after 10 to 12 days postoperatively. The pouch is drained for 21 days before training by intermittent catheter clamping. All patients start self-catheterization 2 days before discharge from the hospital. A 2-hour interval is allowed in week 1, which is increased gradually until the pouch matures. By the end of week 6, most of the patients evacuate the pouch every 4 to 5 hours.

OUTCOMES

Complications

In our experience with 101 patients, early complications were observed in 15%. These included urinary leakage (2%), pelvic collections (8%), ureteroileal obstruction (1%), ileus (3%), and wound complications (3%). Small nonsymptomatic pelvic collections need no treatment. Sizable and/or infected symptomatic ones are usually treated by ultrasound-guided needle aspiration with or without an indwelling tube drain. None of these pelvic collections required open drainage. Urinary leakage was an infrequent complication in our series (2%). This complication was due to pouch perforation during catheterization training. Prolonged pouch drainage was required for an additional 2 weeks until healing of the injury occurred. Early evidence of ureteroileal obstruction was observed in one patient. Antegrade fixation of a double-J stent was done for 6 weeks. The stent was removed by pouchoscopy carried out through the umbilical stoma. Gastrointestinal and wound complications were similar to those for other urinary diversion procedures.

Late complications included stomal stenosis at the skin level with catheterization difficulties in 6% of the patients. Two-thirds of them had an appendix stoma. Half of these patients required revisional surgery to widen the mucocutaneous stenotic area using a wedge skin flap technique. In one child, it was impossible to pass a catheter into the pouch due to overdistention resulting in angulations of the outlet tract. Under ultrasound guidance, percutaneous insertion of a pigtail catheter was carried out. Once the pouch became empty, outlet catheterization again was easy. Rupture of the pouch was observed in one patient following blunt abdominal trauma. Laparotomy was necessary, and the pouch tear was adequately repaired. Pouch stones were observed in 5% of the patients. All of them were amenable for endoscopic manipulations, but one patient required open pouch lithotomy. The incidence of upper tract dilatation due to anastomotic stricture was minimal (1%); the stricture was treated by antegrade balloon dilatation. One patient required left nephroureterectomy 3 years following cystectomy due to a renal pelvis tumor. Gravity pouchography demonstrated reflux in three patients (3%). Reflux was asymptomatic in all, and the patients were kept on prophylactic antimicrobial suppressive therapy. None of the operated patients developed metabolic acidosis. All patients were advised to use oral alkali therapy.

Results

Patients regained their normal lifestyle once healing was completed. Ninety-five percent of our patients were completely dry day and night. The catheterization interval was every 4 to 5 hours during daytime and every 1 to 2 hours at night. The average capacity at 6 months postoperatively was 550 ± 130 mL.

Five patients (5%) had a frequently wet stoma due to failure of the continence mechanism. Two patients were revised. One underwent revision of the continent outlet, and augmentation ileopouchoplasty was required to increase pouch capacity in the other. Two patients preferred frequent catheterization to avoid leakage. The remaining patient fixed a collection device during nighttime and refused further intervention.

Patients have to understand that they have a neobladder constructed from the bowel and that this bladder is different from the native one. The usual desire to micturate and the familiar micturition mechanism no longer exist. However, all patients with a dry, continent outlet stoma enjoy an excellent lifestyle, normal social activities, an accepted body image, and personal satisfaction.

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CHAPTER 82 ■ CONTINENT CATHETERIZABLE RESERVOIR MADE FROM COLON

HUBERTUS RIEDMILLER, ELMAR W. GERHARZ, AND ARKADIUS KOCOT

INDICATIONS

The most common indication for continent cutaneous diversion is bladder replacement after anterior pelvic exenteration for malignant disease, followed by functional or morphologic bladder loss for other reasons. Diagnostic modalities therefore should be directed at the underlying pathology and definitive treatment. Despite the recent trend toward orthotopic substitution, continent catheterizable diversions are still a good form of diversion. Whereas previous or synchronous urethral transitional cell carcinoma (TCC) is an absolute contraindication to urethral preservation, the role of multifocality, associated carcinoma in situ, bladder neck, and prostatic involvement on urethral recurrence are less well defined. In these cases, continent cutaneous diversion still is a safe alternative in the appropriate patient. Advanced age (older than 70 years) with its physiologic deterioration of sphincter competence is another contraindication for orthotopic reconstruction; older patients who are otherwise physically fit may well benefit from a continent cutaneous reservoir. Whenever the native sphincter mechanism is lacking, destroyed, or dysfunctional or urethral catheterization is painful or technically impossible, cutaneous diversion is the only alternative to modified ureterosigmoidostomy and ileal loop. As salvage procedure in failed exstrophy reconstruction, other complicated congenital abnormalities of the urinary tract, neurogenic bladder dysfunction (wheelchair-bound myelomeningocele patients), otherwise intractable urinary incontinence, severe pelvic trauma, and complicated fistulas, continent cutaneous reservoirs provide excellent results even in extremely complex cases.

Until recently, renal transplant patients were excluded from the benefits of continent urinary diversion. Recently, several authors reported encouraging experiences with kidney transplantation into continent urinary intestinal reservoirs as a planned two-stage procedure in patients with functional or morphologic bladder loss (see the following text) (1,2). But long-term results in larger series of patients are still missing.

Other factors to consider when deciding on the type of urinary diversion include patient age, prognosis of underlying disease, comorbidity, urinary and anal sphincter competence, manual dexterity, renal function and upper urinary tract configuration, and subjective criteria (motivation, compliance, expectation of social support, emotional capability of dealing with clean intermittent catheterization). Patient priorities are considered whenever medically justifiable and technically feasible.

Contraindications of continent urinary diversion include impaired renal function with serum creatinine greater than 2 mg per L (other authors choose a cutoff level of 1.5 mg per L), inflammatory bowel disease, large bowel malignancy, or previous history of multiple bowel ablative procedures, and history of diarrhea.

ALTERNATIVE THERAPY

Alternatives to catheterizable colonic reservoirs include pouches made from ileum (Kock), ileal or colonic conduits, classic and modified ureterosigmoidostomy (e.g., sigma rectum pouch/Mainz pouch II), and orthotopic neobladder (Hautmann, Studer).

SURGICAL TECHNIQUE

While there is a broad consensus among reconstructive urologists regarding detubularization and spheric reconfiguration of bowel as basic principle in the creation of a low-pressure, high-capacity reservoir, the issues of reflux prevention (afferent limb), and continence (efferent limb) are more controversial. The still growing number of techniques described for achieving continence in urinary reconstruction indicates that a universally applicable procedure with a low complication rate has not yet evolved. The principal methods for construction of a continence mechanism depend either on the formation of a nipple valve, utilization of the ileocecal valve, or construction of a flap valve. Among the different techniques, the versatile Mitrofanoff principle (3) has reached significant popularity, predictably providing continence and allowing easy catheterization in more than 90% of cases. In 1990, Riedmiller et al. introduced the Mitrofanoff theme to the ileocecal reservoir, significantly facilitating the Mainz pouch procedure (4).

When performing a Mitrofanoff, the method of attachment of the appendix to the reservoir (reversed, in situ; imbricated, embedded, unaltered), the location of the stoma (umbilicus, lower abdomen), and appropriate alternatives remain controversial. It is known that the success of the Mitrofanoff principle is not dependent upon the underlying pathologic condition, the type of tube and its possible peristalsis, the type and configuration of the reservoir, or the patient’s age but the maintenance of a pressure gradient between channel lumen and the reservoir. It is therefore the availability of the required material and the simplicity of a technique that determine its popularity. Recent variations of the Mitrofanoff theme have aimed at its simplification and reduction of long-term complications.

Ileocecal Pouch (Mainz Pouch I)

Intussuscepted Ileal Nipple

After mobilization of cecum, ascending colon, and the right colonic flexure, the mesentery is divided between the right colic and the ileocolic artery. A 13-cm segment of cecum and ascending colon is isolated along with two equal-sized limbs of distal ileum. If the vermiform appendix is absent as in cloacal exstrophy, completely obliterated, immobile, insufficient in diameter and length, or had been removed beforehand, we usually isolate an additional portion of ileum measuring 10 to 12 cm (Fig. 82.1A). While the latter is left tubularized, the remaining bowel segment is split antimesenterically. These three opened bowel loops are folded in the form of an incomplete W, and their posterior aspects are sutured to one another to form a broad posterior plate (Fig. 82.1B). Both ureters are implanted into the large bowel segment of the pouch plate, forming submucosal tunnels for reflux prevention (Fig. 82.1C).

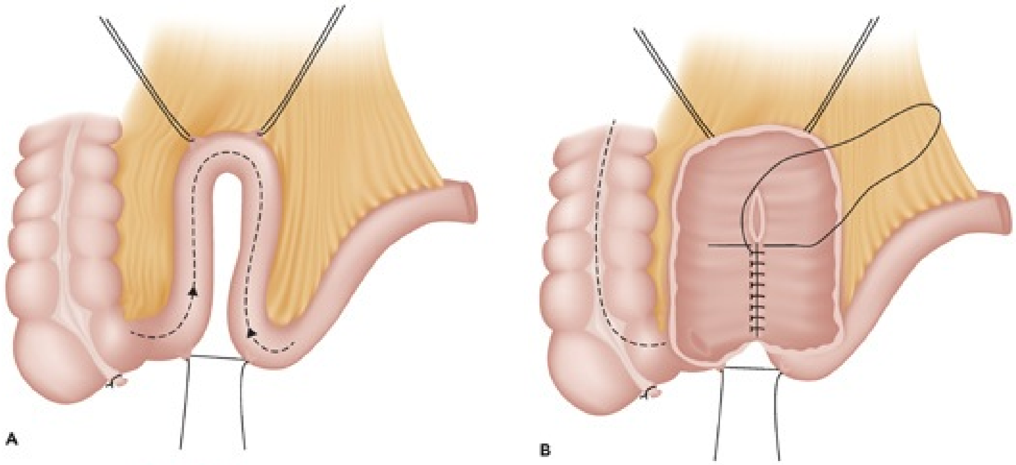

FIGURE 82.1 Ileocecal pouch (Mainz pouch I) with IIN valve. **A:** Isolation of the cecum/ascending colon (13 to 15 cm) and two equal-sized ileal loops (13 cm each) for reservoir formation and an additional ileal segment (10 to 12 cm) for nipple formation. Antimesenteric splitting of the bowel. **B:** Side-to-side anastomosis of the terminal and next proximal ileal loop with subsequent detubularization of the ascending colon. *(continued)*

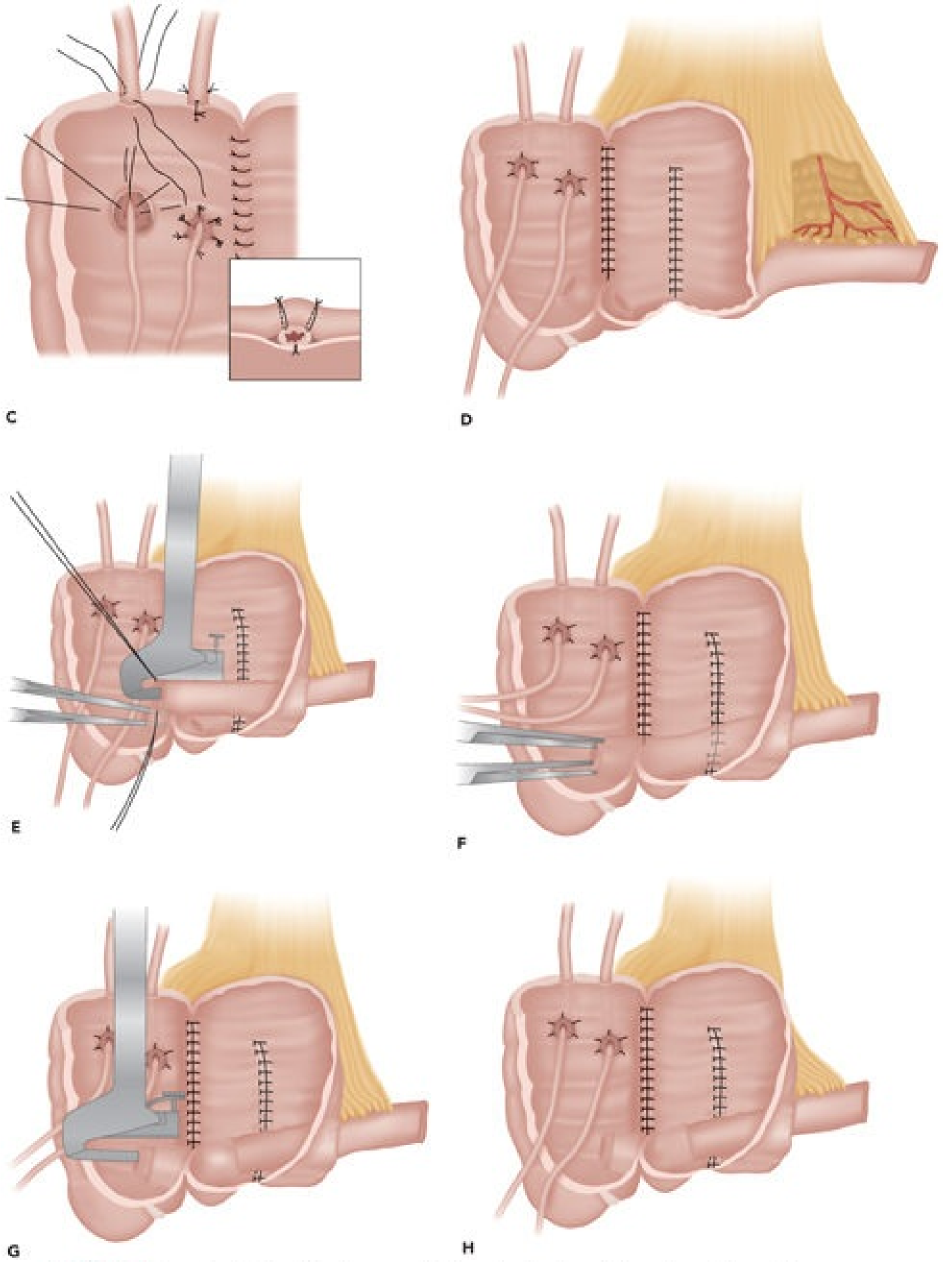

FIGURE 82.1 *(continued)* **C:** Antirefluxing ureteral implantation into the colonic portion of the pouch plate using submucosal tunnels (3 cm length) with insertion of 6Fr or 8Fr ureteral stents. **D:** Removal of mesentery (4 to 5 cm) in the midportion of the most proximal intact ileal segment in preparation for intussusception. **E:** Intussusception of the ileal segment and stabilization by applying one row of staples. **F:** The IIN pulled through the ileocecal valve. **G:** Two additional rows of staples are used to attach the nipple to the valve. **H:** Completed attachment of the nipple to the valve.

The midportion of the intact ileal segment is freed of its mesentery for a distance of 4 to 5 cm to allow its intussusception (Fig. 82.1D and E). We apply only one row of staples to stabilize the intussusception itself (Fig. 82.1F). Thereafter, the intussuscepted nipple is pulled through the intact ileocecal valve and two additional rows of staples are applied to attach the nipple to the ileocecal valve. After the mucosa has been removed from the rim of the intussuscepted nipple and the colonic aspect of the ileocecal valve, their circumferences are sewn together with a resorbable running suture.

The bowel is then folded on itself in a side-to-side fashion, thus creating a low-pressure and high-capacity reservoir. Ureteral stents (6Fr or 8Fr) and a 10Fr pouchostomy are led through the abdominal wall at separate sites. The entire pouch is rotated so as to bring the efferent limb to the region of the umbilicus. A small button of skin is removed from the depth of the umbilical funnel. The pouch is carefully attached to the posterior fascia with interrupted nonabsorbable sutures to prevent the pouch from rotating and kinking. The efferent limb is then connected to the umbilical funnel with interrupted absorbable sutures. If no umbilicus is present (as in the case of exstrophy), it is created by tubularizing a V-shaped cutaneous flap and connecting it to the appendicular stump.

A vigorous washout regimen is started early in the postoperative course. Ureter stents are removed after 10 to 14 days. Clean intermittent catheterization is usually started at the end of postoperative week 3 after leakage and reflux has been ruled out by pouchogram.

Appendix Stoma

If the appendix is present and can be dilated to accommodate a 16Fr to 18Fr catheter, it is our first choice as ideal efferent segment for construction of a continence mechanism. In this case, a 15-cm segment of cecum and ascending colon is isolated along with two equal-sized limbs of distal ileum (12 to 13 cm each). The lower 5 cm of the cecum (cecal pole) is left tubularized and intact. The seromuscular layer of the intact cecal pole is divided along the tenia down to the mucosa analogous to the Lich-Gregoir procedure for vesicoureteral reflux (Fig. 82.2A). By careful dissection of the seromuscular tissue, a broad submucosal bed (5 cm in length) is created for the appendix.

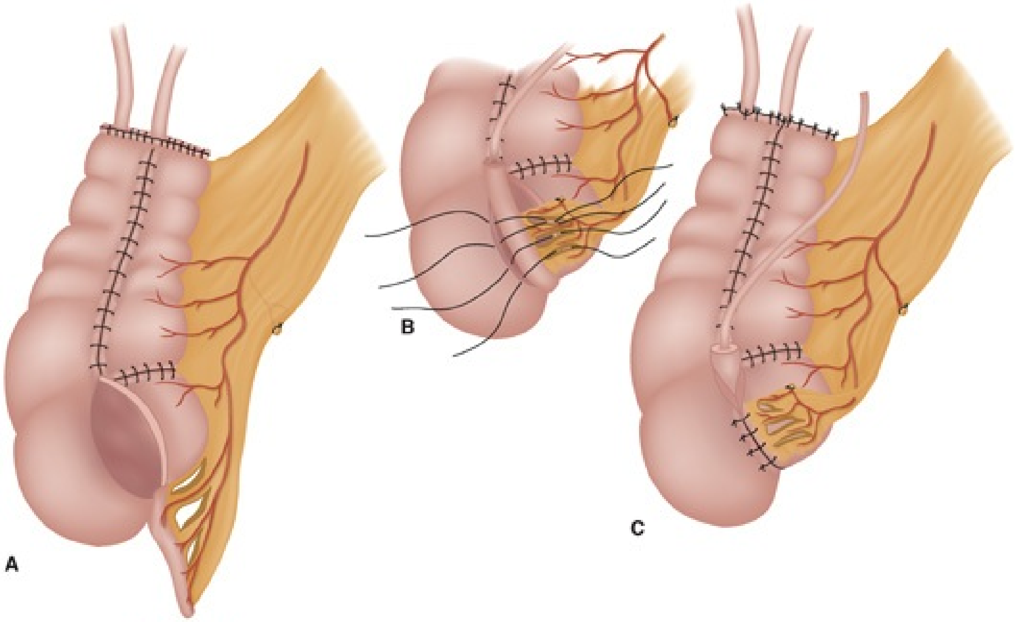

FIGURE 82.2 Ileocecal pouch (Mainz pouch I) with appendix stoma. **A:** The seromuscular layer of the intact cecal pole is split along the tenia down to the mucosa; a broad submucosal bed (5 cm in length) for the appendix is created. **B:** Windows in the mesoappendix are excised between the branches of the appendicular artery without compromising the blood supply. **C:** After the appendix is correctly positioned, the seromuscular layer is closed over the embedded in situ appendix.

The appendicular mesentery is freed of its excessive fatty tissue. Windows in the mesoappendix are excised between the branches of the appendicular artery without compromising the blood supply (Fig. 82.2B). Anatomic variations of the appendicular artery have to be respected, and an additional branch of the anterior or posterior cecal artery supplying the base of the appendix should be preserved. After the appendix is correctly positioned, the seromuscular layer is closed over the embedded in situ appendix with interrupted 4-0 polydioxanone sutures. A short mobile portion of the distal appendix remains for creation of the appendicoumbilical stoma (Fig. 82.2C). Formation of the pouch plate, ureterointestinal anastomosis, and attachment to the umbilicus are identical to the pouch with intussuscepted nipple.

Alternative Techniques for Construction of Continence Mechanism

More recent alternative techniques use a small-caliber conduit fashioned from the cecal wall. One technique uses a full-thickness tube lined by mucosa (Fig. 82.3A and B) and the other, a seromuscular tube lined by serosa (Fig. 82.4A–C) (5). Other authors have described transversely retubularized ileum (Fig. 82.5A–C) to create a tunneled access into the right colon (6).

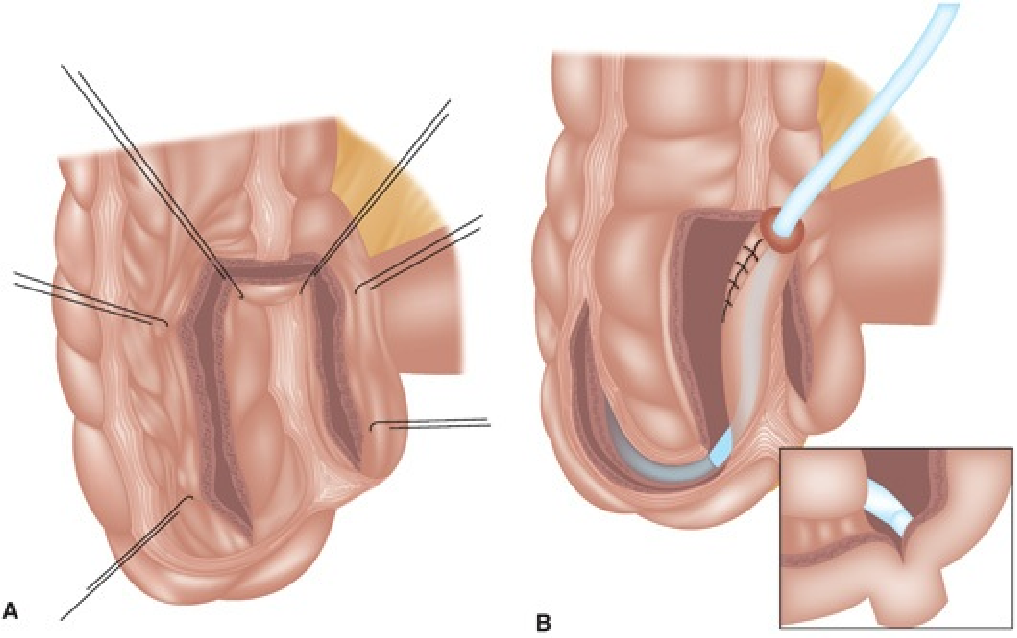

FIGURE 82.3 Full-thickness bowel flap tube. **A:** U-shaped incision (3 cm × 6 cm) of all layers of bowel wall resulting in pedicled bowel flap at the lower pole of the cecum. **B:** Tubularization of pedicled flap over an 18Fr Foley catheter and incision of the seromuscularis of the tenia omentalis (5 cm) for submucosal embedding starting at the pedicle of the bowel flap tube.

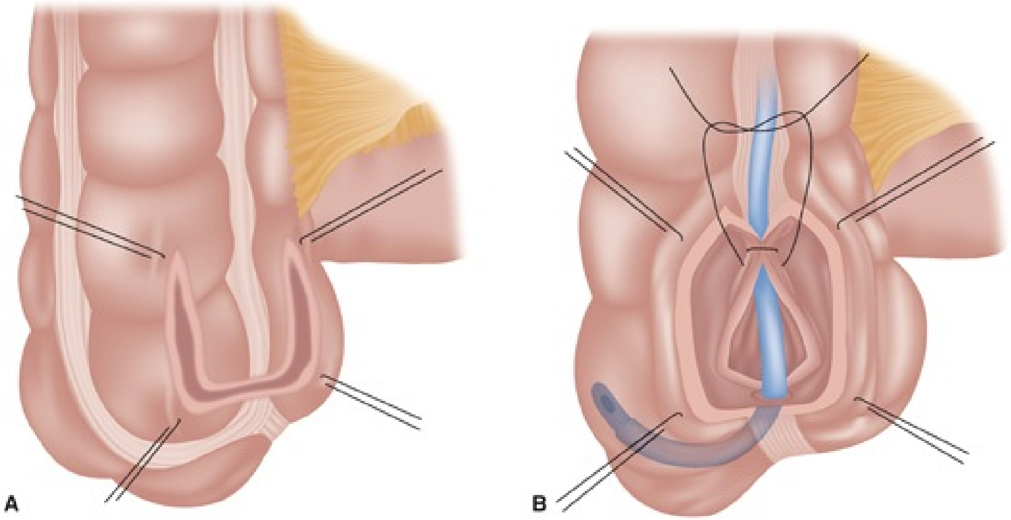

FIGURE 82.4 Seromuscular bowel flap tube. **A:** U-shaped incision (3 cm × 5 cm) of seromuscular layer at the lower pole of cecum and transverse incision of mucosa (0.5 cm) at the oral end of flap for insertion of an 18Fr Foley catheter into the lumen of the *reservoir*. **B:** Tubularization of the seromuscular bowel flap *over* an 18Fr Foley catheter. *(continued)*

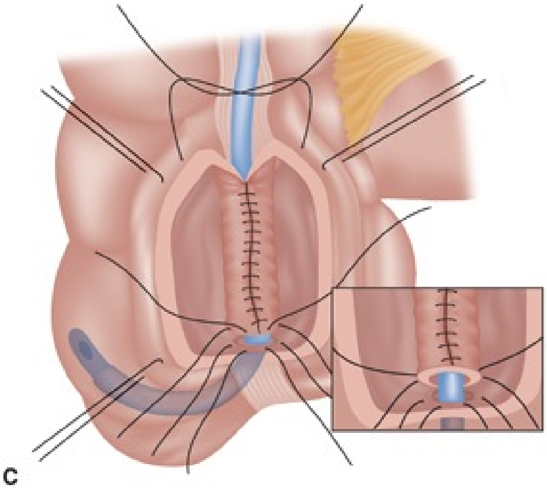

FIGURE 82.4 *(continued)* C: Suturing of anterior circumference of the seromuscular tube to the margin of mucosa (*inset*).

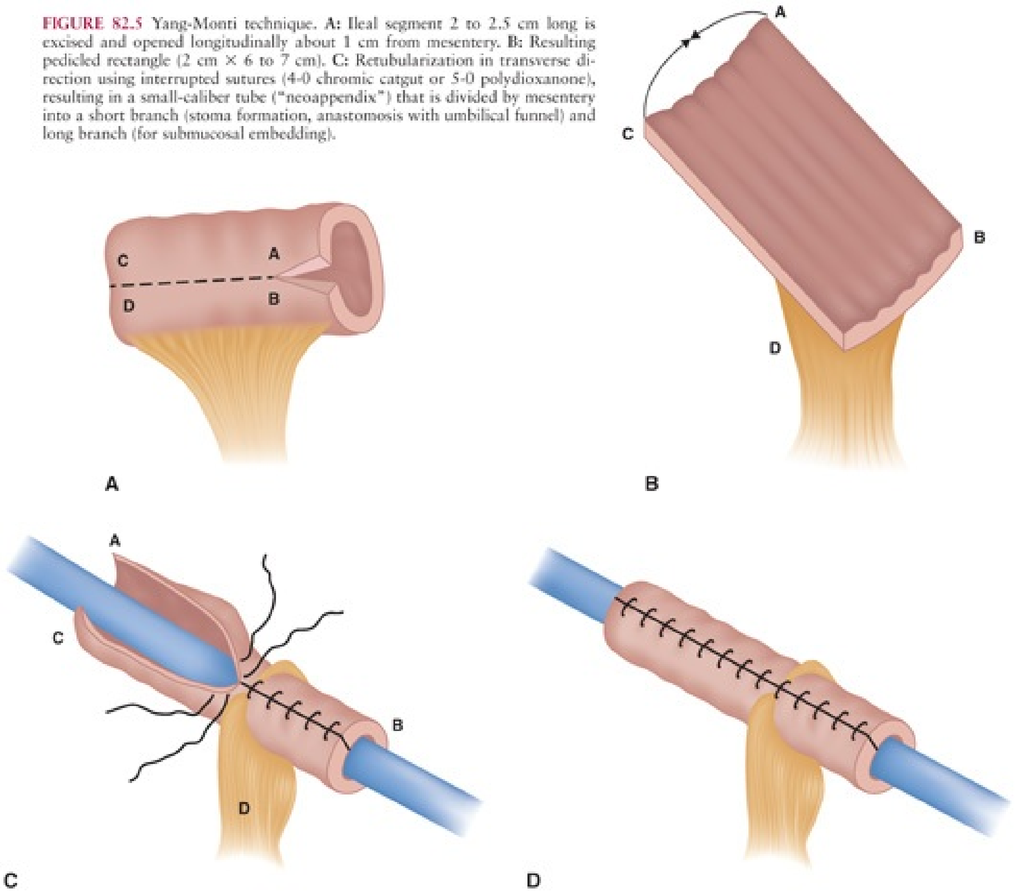

FIGURE 82.5 Yang-Monti technique. A: Ileal segment 2 to 2.5 cm long is excised and opened longitudinally about 1 cm from mesentery. B: Resulting pedicled rectangle (2 cm × 6 to 7 cm). C: Retubularization in transverse direction using interrupted sutures (4-0 chromic catgut or 5-0 polydioxanone), resulting in a small-caliber tube ("neoappendix") that is divided by mesentery into a short branch (stoma formation, anastomosis with umbilical funnel) and long branch (for submucosal embedding).

Alternative Techniques for Ureteral Implantation

In dilated, irradiated, or otherwise compromised ureters, ureterointestinal anastomosis may be performed according to a technique that has been described by Abol-Enein and Ghoneim (serous-lined extramural tunnel) (Fig. 82.6A and B) (7).

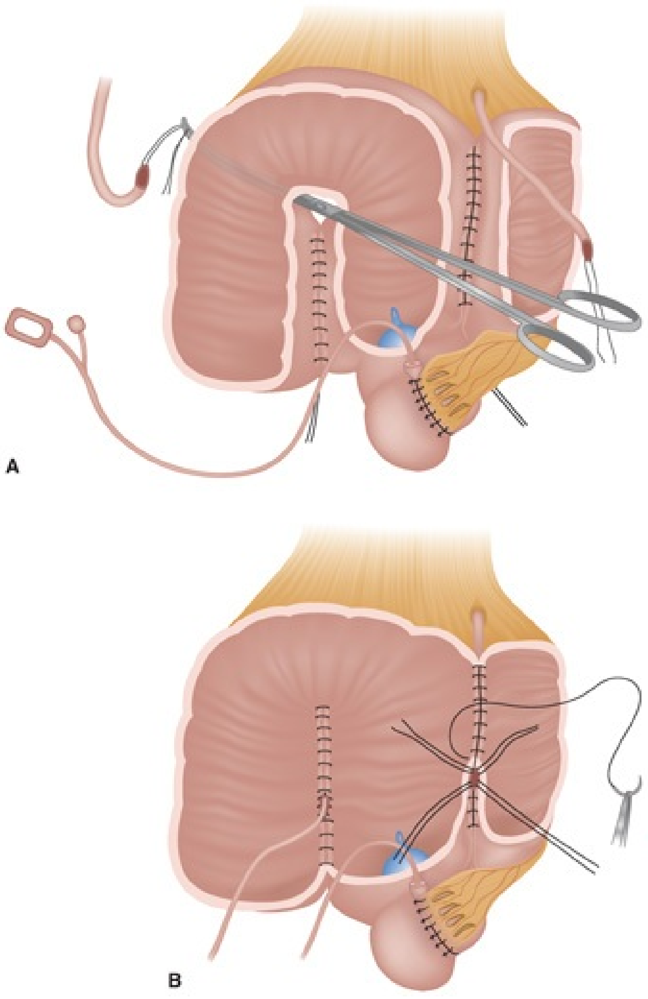

FIGURE 82.6 Ileocecal pouch (Mainz pouch I) with serous-lined implantation of ureters. **A:** In contrast to the original technique, the pouch plate is not created by anastomosing the edges of detubularized bowel segments but by creating two serous-lined extramural troughs. **B:** The ureters are placed into the serous-lined tunnels and covered by approximating the margins of the detubularization.

Right Colon Pouches with Intussuscepted or Embedded Tapered Terminal Ileum

Several other authors use the ileocecal region in continent cutaneous urinary diversion. In contrast to the Mainz technique, they employ the ileum for construction of the continence mechanism but not for creation of the reservoir itself. Other colon pouches using nipple valve technology for the continence mechanism include modifications from many other centers and differ from one another by only a few features, predominantly related to the technique employed for stabilizing the nipple valve. In the “Tiflis” technique, the continence mechanism is created by tapering and submucosal embedding of terminal ileum (Fig. 82.7A and B) (8).

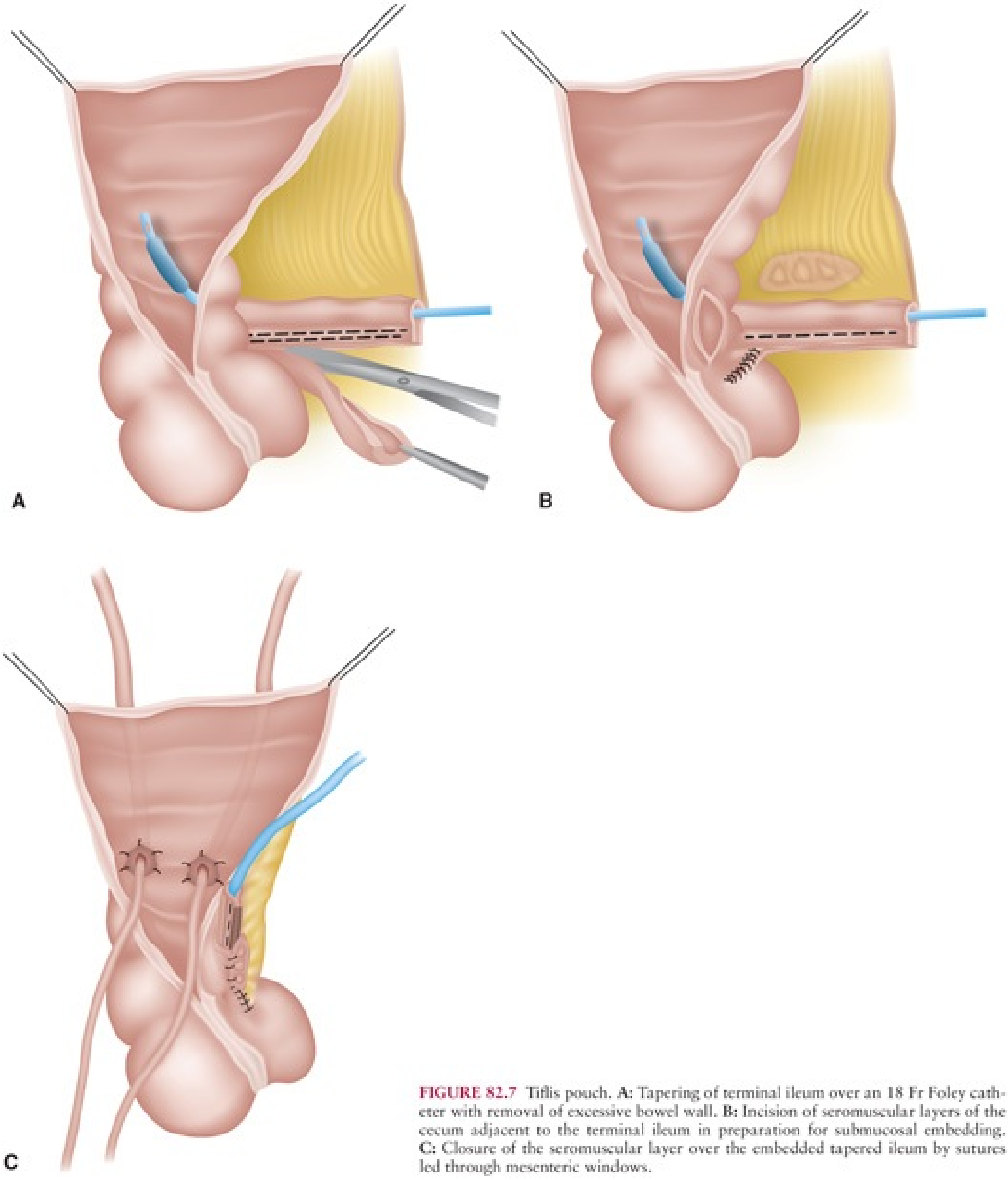

FIGURE 82.7 Tiflis pouch. **A:** Tapering of terminal ileum over an 18 Fr Foley catheter with removal of excessive bowel wall. **B:** Incision of seromuscular layers of the cecum adjacent to the terminal ileum in preparation for submucosal embedding. **C:** Closure of the seromuscular layer over the embedded tapered ileum by sutures led through mesenteric windows.

Indiana Pouch

Between 25 and 30 cm of cecum and ascending colon and 8 to 10 cm of terminal ileum are isolated (9). The entire colonic segment will be detubularized by incising it along its antimesenteric surface. If an appendix is present, it is removed at this time. Reconfiguration of the opened bowel segment by folding the cephalad end down to the apex of the antimesenteric incision allows creation of a spheric reservoir (Fig. 82.8A). For construction of the efferent limb and continence mechanism, metal staples are applied sequentially to narrow the efferent limb over a 12Fr straight catheter (Fig. 82.8B). Excess antimesenteric ileum is removed. The last row of staples is placed at an angle to prevent stapling into the wall of the cecum. After narrowing the efferent limb, the ileocecal valve area is plicated with five to seven Lembert stitches of 3-0 silk suture (Fig. 82.8C). Care is taken to avoid having the sutures enter the lumen of the bowel. Each Lembert suture is progressively wider than the last. This has the effect of narrowing the ileocecal valve by wrapping cecal wall over the angled staple line. The tightness of the plication sutures is tested by passing an 18Fr catheter through the efferent limb. Once the efferent limb and continence mechanism have been completed and a Malecot catheter has been placed as cecostomy tube in the dependent portion of the cecum, the reservoir is closed. Both ureters are led in such a manner as to allow alignment with a tenia. A tenial incision is made for each ureter. The ureter is cut obliquely or spatulated, and the site for the ureteral orifice is created by incising the bowel mucosa. The ureteromucosal anastomosis is performed with interrupted sutures of 5-0 synthetic absorbable monofile material. The tenia is reapproximated over the ureter with a nonabsorbable 5-0 suture.

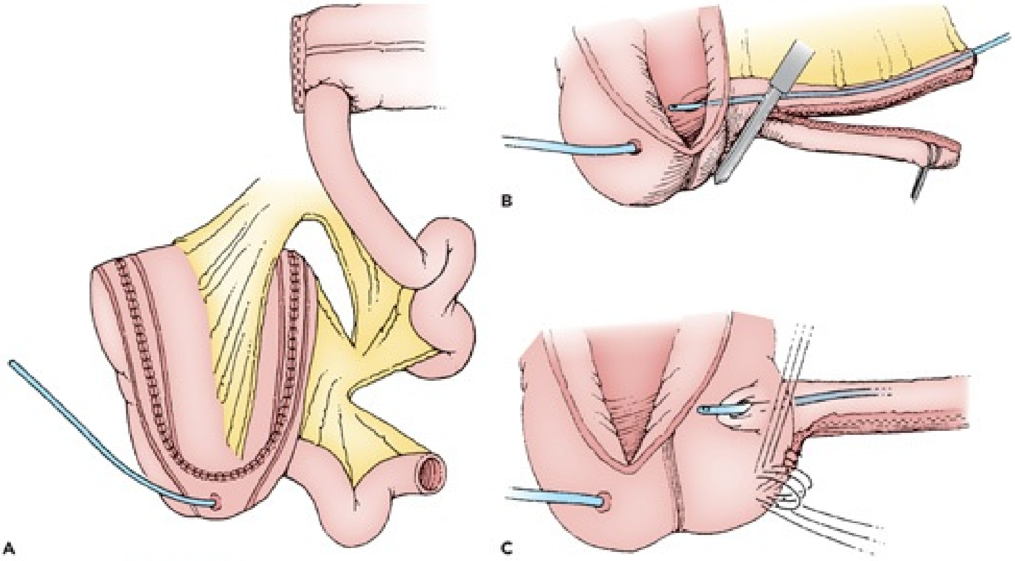

FIGURE 82.8 Indiana pouch. **A:** The cephalad end of the detubularized right colon segment is folded caudally to the apex of antimesenteric incision. A Malecot catheter is placed in the dependent portion of the cecum prior to closing the reservoir. **B:** A stapler is used to trim away the excess bowel wall of the ileal segment (tapering). **C:** A total of five to seven Lembert sutures are placed to plicate the ileocecal valve.

Colon Pouch (Mainz Pouch III)

Between 15 and 17 cm of transverse colon and either ascending (transverse-ascending pouch [TAP]) or descending colon (transverse-descending pouch [TDP]) (Fig. 82.9A) is required to create a pouch of adequate capacity (350 to 400 mL) (10). Complete mobilization of the right or left colonic flexure should be performed to gain adequate colon length for the pouch. The greater omentum is dissected from the transverse colon from right to left in the TAP and vice versa in the TDP. The bowel segment is detubularized antimesenterically, leaving 5 to 6 cm of the oral or aboral end intact for construction of the efferent limb. The terminal segment is tapered over an 18Fr silicone catheter, thus creating a neoappendix (Fig. 82.9B). Mucosa is sewn with polyglycol suture and the seromuscular layer with a nonabsorbable running suture, serous-lined implantation of ureters. Easy insertion of the catheter is important as a shrinkage of approximately 30% has to be reckoned with. After the pouch plate is created, antirefluxing ureterointestinal implantation is performed on both sides of the suture line (Fig. 82.9C). For refluxing ureteral implantation, about 1 cm^2 of the bowel mucosa is excised and the seromuscular layer is incised in the shape of a cross. After anchor sutures at the 5 and 7 o’clock positions are placed, a watertight anastomosis with 5-0 Monocryl sutures is performed. Ureteral stents and a 10Fr pouchostomy are led through the abdominal wall at separate sites.

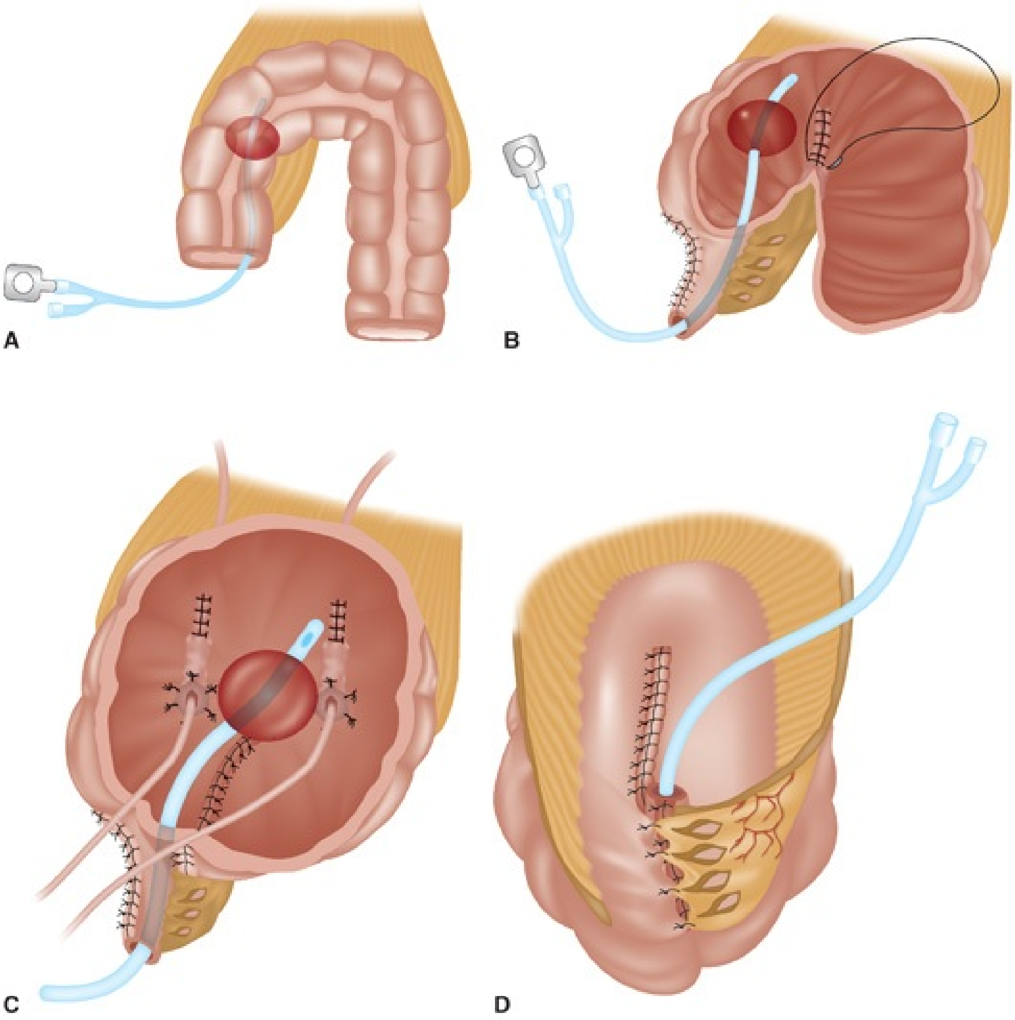

FIGURE 82.9 Colon pouch (Mainz pouch III) with tapered colon as efferent limb. **A:** About 15 to 17 cm of nonirradiated large bowel are isolated for reservoir creation. The oral end with a Foley catheter is used for construction of efferent limb. **B:** The colonic segment is detubularized and the pouch plate is formed. The oral end is tapered over an 18Fr Foley catheter and windows are made in the mesentery. **C:** The ureters are attached to the posterior pouch wall through a submucosal tunnel. **D:** Pouch formation is completed by closing the anterior wall. The efferent segment is embedded serosa-to-serosa by sutures led through mesenteric windows.

The pouch is closed and the efferent segment is established. Windows are dissected in the mesentery of the tapered colon between the vessels. The efferent limb is then placed in the suture line, and the seromuscular layer of the anterior wall is approximated through the windows in the mesentery (Fig. 82.9D). Our favorite technique comprises isolation of a short segment of jejunum or ileum, which is tapered over an 18Fr Foley catheter and embedded submucosally after incising the tenia of a tubularized portion of the colonic segment. Sutures are led through windows in the ileal mesentery (Fig. 82.10A–D).

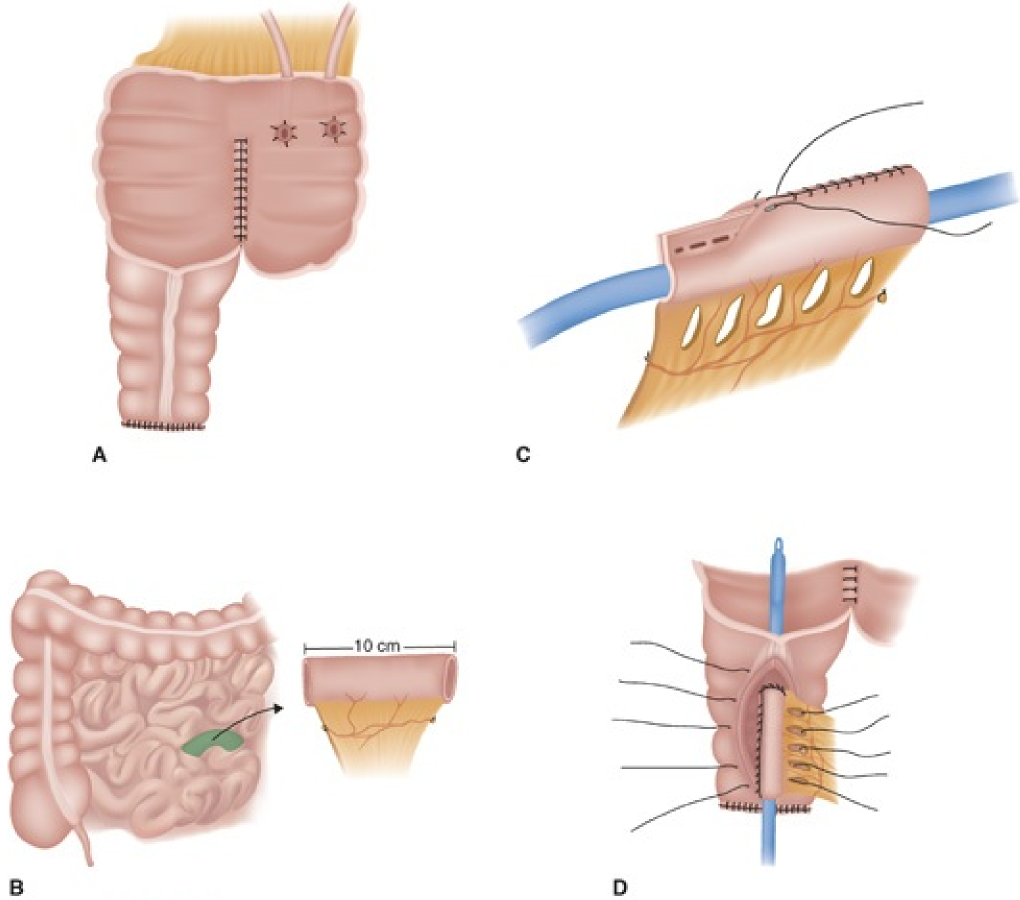

FIGURE 82.10 Colon pouch (Mainz pouch III) with tapered small bowel as efferent limb. **A:** The oral end of the large bowel segment is closed and left intact. **B:** A 10-cm jejunal or ileal segment is isolated with careful preservation of its mesenteric pedicle. **C:** The ileal segment is tapered over an 18Fr Foley catheter, trimming away the excess bowel wall. The tube is formed using a running suture. Windows are created between the vasculature of the mesentery. **D:** Submucosal embedding of tapered ileum after incision of the seromuscular layer of the tenia of the intact colonic segment. Sutures are led through mesenteric windows.

The umbilicointestinal anastomosis is performed in the same fashion as in the ileocecal pouch. Finally, the reservoir is attached to the abdominal wall. The greater omentum is used to cover the pouch and bowel. Ureter stents are removed after 10 to 14 days. Clean intermittent catheterization is started 3 weeks postoperatively.

OUTCOMES

Complications and Prevention

While continence using the appendix, once established, is durable with late-onset failure of 1% to 2% at about 4 years, stomal stenosis is seen in 8% to 23% of patients, depending on the length of follow-up. Although stenosis represents a minor technical problem, the subsequent inability to insert the catheter is a distressing complication with potentially serious consequences in patients in whom the Mitrofanoff channel is the only route of evacuation. In these cases, the reservoir must be immediately emptied percutaneously, which is facilitated by fixation of the pouch to the abdominal wall.

Skin stenosis may be dilated, incised, or repaired by open surgery, carefully removing fibrotic tissue. According to our experience, dilatation alone seldom produces a lasting improvement. We therefore tend to early intervention. Although revisions are usually successful, prevention of stenosis is desirable. Stomal stenosis can be avoided by incorporation of a V-shaped flap of umbilical funnel into the spatulated appendix. To prevent recurrence, we have developed a cone-shaped metal dilator. Its effective length was designed to cover only the known critical segment of the channel. Directly before inserting the catheter for evacuation of the reservoir, the stoma is gently dilated for a few minutes once or twice daily. A similar effect might be produced by occasionally leaving the catheter in the pouch at night.

Complications of intussuscepted ileal nipples resulting in impaired clean intermittent self-catheterization and/or urinary incontinence may be caused by nipple gliding, prolapse, or, in the worst case, by nipple necrosis. Initial complication rates for sutured or stapled ileal intussusception nipples were significantly reduced, when the intussuscepted ileal segment was additionally fixed to the ileocecal valve and the wall of the reservoir by metal staples (11). Obesity has been identified as a significant risk factor for nipple gliding.

Ureterointestinal stenosis is the most frequent complication of the upper urinary tract and ranges between 2% and 15% for submucosally implanted ureters into colonic segments and between 2.9% and 5.1% for ureters, with a serosa-lined extramural tunnel within a mean follow-up of 91.1 months (range 4.3 to 220.2 months) (12). Most discussed factors for ureterointestinal stenosis are fibrosis and inflammatory changes, previous surgery or radiation, preexisting ureteral dilatation, and urinary leakage. Differential choice of surgical technique during ureteral implantation is mandatory to reduce the risk of anastomotic strictures.

Metabolic complications are due to either reduction of the absorptive bowel capacity through functional loss of those segments required for reservoir construction or the highly unphysiologic exposure of the reconfigured bowel to urine. Factors that affect solute absorption include the size and segment of bowel used, time of retention of urine, concentration of the solutes in the urine, renal function, and pH and osmolality of the fluid (13,14).

The most common consequence of intestinal urinary diversion is metabolic acidosis. Depending on definition, diagnostic modality, reservoir characteristics, renal function, and length of follow-up, it has been reported in 20% to 100% of patients after ureterosigmoidostomy, bladder substitution, and continent diversion using ileal and/or colonic segments.

Intestinal urinary reservoirs have an increased propensity to form urinary calculi, predominately as well in the upper as in the lower which frequently recur with an increasing incidence over time.

Pouch urolithiasis is a well-known complication of continent cutaneous diversion with an incidence of approximately 5% to 25% (15–17).

Risk factors include the presence of foreign material (e.g., staples), recurrent and chronic infection, composition of the urine, mucus production, urinary stasis, and noncompliance with irrigation and catheterization regimens.

Stone formation in pouches is best managed by prevention. This includes the treatment of symptomatic infections and daily irrigations to reduce mucus retention.

Bile stones in pouch patients are reported with an incidence of 11% comparable to the 10% to 20% incidence in the normal population (17,18).

Spontaneous rupture or perforation during catheterization has been observed after bladder augmentation, orthotopic ileal, and ileocolonic bladder replacement and in continent cutaneous reservoirs 4 weeks to more than 5 years after surgery.

Hypovitaminosis is a well-studied sequela to resection of bowel, and in particular on vitamin B_{12}, as patients may develop irreversible neurologic disease in case of unrecognized deficiency. Substitution of vitamin B_{12} is simple and even less expensive than regular determination. Empirical supplementation may therefore be considered.

Bile acids with consecutive laxative effect might cause chologenic diarrhea with an incidence up to 30% in patients with ileocecal urinary reservoirs but can successfully be managed with loperamide or cholestyramine.

In the risk group of patients with stool frequency already prior to surgery, reconstruction of the ileocecal valve is recommended (17).

Troubleshooting

Ureterointestinal Stenosis

The general causes of ureteroenteric strictures in continent cutaneous diversion are similar to those in conduit diversion with basic etiologic factors including failure to achieve mucosal-to-mucosal apposition, tension at the anastomosis, tissue is chemia, radiation injury, and recurrent malignancy (19).

Due to the very low success rate of dilatation and stenting procedures, early neoimplantation is the treatment of choice in most cases. In our experience, a modified Lich-Gregoir procedure (20) has proven to be a very effective option (Fig. 82.11). In a cohort of 30 patients with ureterointestinal stenosis, ureteral reimplantation was performed successfully in 36 of 37 renal units (mean follow-up: 53 [range: 3 to 166] months).

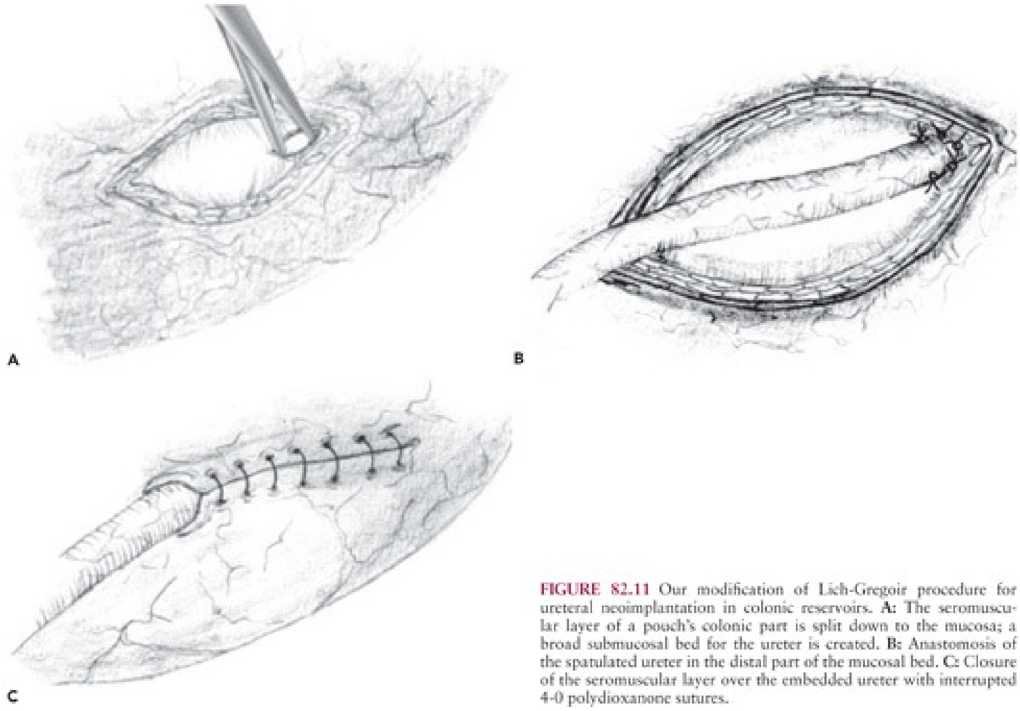

FIGURE 82.11 Our modification of Lich-Gregoir procedure for ureteral neoimplantation in colonic reservoirs. A: The seromuscular layer of a pouch's colonic part is split down to the mucosa; a broad submucosal bed for the ureter is created. B: Anastomosis of the spatulated ureter in the distal part of the mucosal bed. C: Closure of the seromuscular layer over the embedded ureter with interrupted 4-0 polydioxanone sutures.

A flank incision (Fig. 82.12) should be chosen as a surgical (retroperitoneal) approach to avoid incision of the laparotomy scar and transabdominal approach to the ureter.

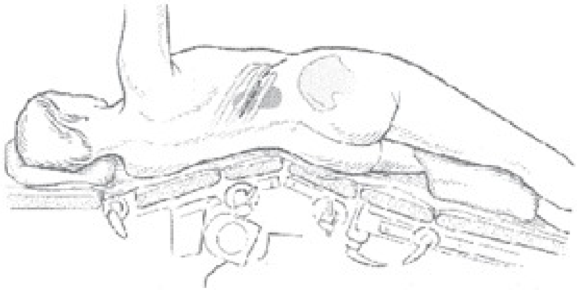

FIGURE 82.12 The patient is placed in a modified flank position.

Partial or total ureteral replacement using ileum might be necessary in severely damaged ureters.

Continence Mechanism

Problems with catheterization can be avoided when paying utmost attention to proper surgical details at the time of continence mechanism creation. Stable and durable fixation of the continence mechanism and a straight course of the continent outlet are mandatory to guarantee ease of catheterization.

High surgical competence, creativity, and variability are required in cases of revisional surgery for stomal insufficiency in continent cutaneous urinary diversion.

Nipple prolapse in ileocecal reservoirs frequently can be treated by refixation of the nipple to the ileocecal valve (Fig. 82.13)

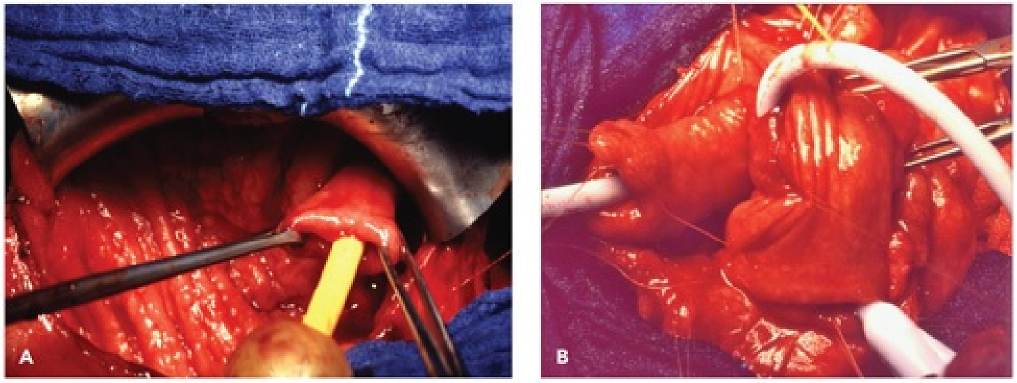

FIGURE 82.13 Nipple gliding. A: Open pouch, IIN dislocated out of the ileocecal valve. B: IIN relocated and pulled through the ileocecal valve. Refixation with two rows of staples.

In complex cases and especially in the presence of a devastated appendix continence mechanism or of a necrotic ileal nipple, creation of a secondary intussuscepted ileal nipple (IIN) might become necessary.

In revisional surgery of continence mechanisms, laparotomy is inevitable. Sufficient adhesiolysis and at least partial mobilization of the ileocecal reservoir from the abdominal wall are preconditions for successful repair or substitution of the continence mechanism.

In our institution, 16 patients underwent revisional surgery with creation of a secondary IIN. Thereafter, all patients were continent day and night with ease of catheterization. The mean follow-up was 53.9 (range 2 to 159) months. In the long-term setting, no stoma stenosis was observed, but two of these patients required refixation of the secondary IIN due to nipple gliding 36 and 54 months after surgery (Fig. 82.14).

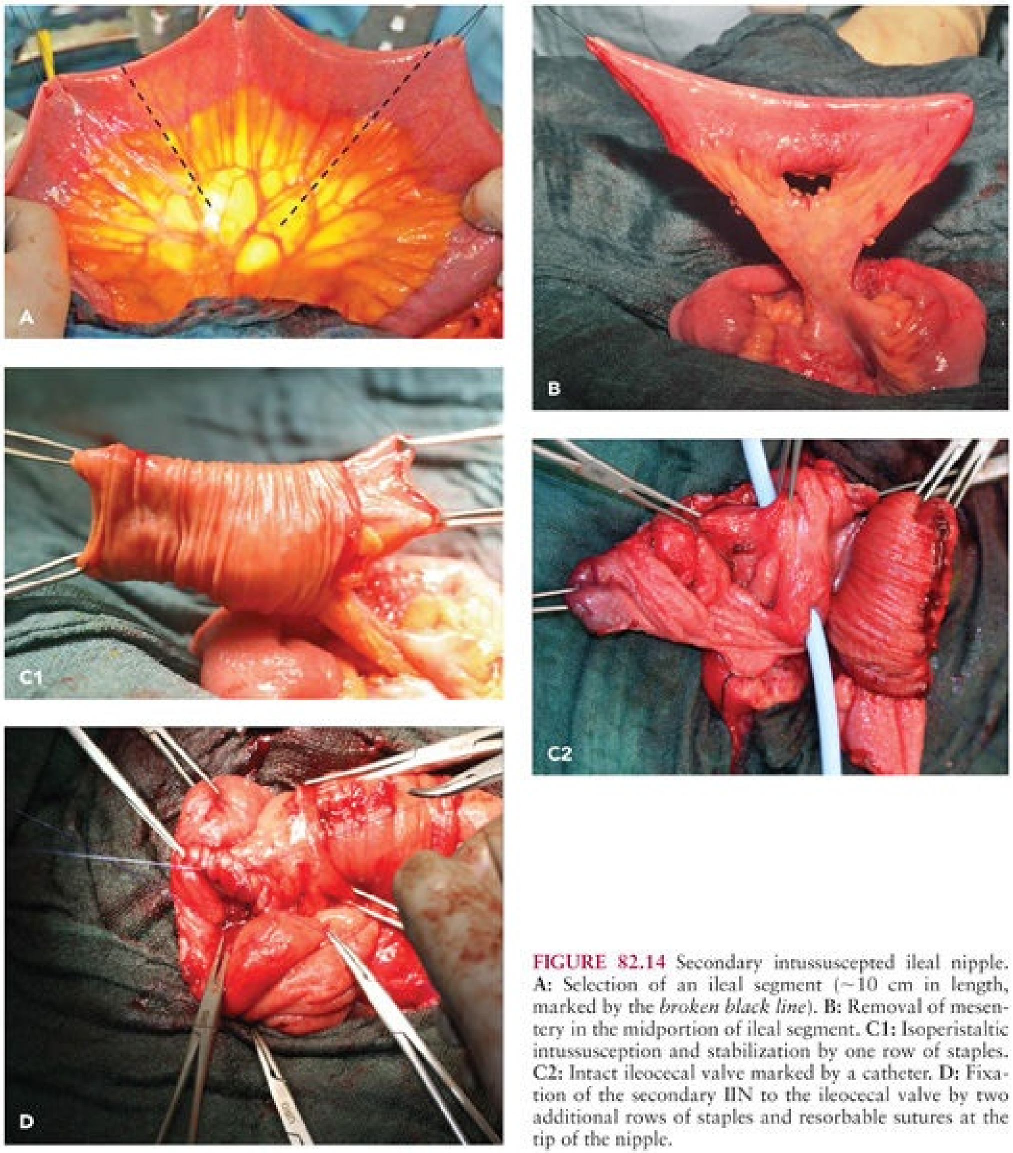

FIGURE 82.14 Secondary intussuscepted ileal nipple. A: Selection of an ileal segment (~10 cm in length, marked by the *broken black line*). B: Removal of mesentery in the midportion of ileal segment. C1: Isoperistaltic intussusception and stabilization by one row of staples. C2: Intact ileocecal valve marked by a catheter. D: Fixation of the secondary IIN to the ileocecal valve by two additional rows of staples and resorbable sutures at the tip of the nipple.

In case of otherwise intractable outlet failure resulting in impaired clean intermittent self-catheterization and/or urinary incontinence, creation of a secondary continence mechanism is also required.

Despite careful planning, in revisional surgery, final decisions about bowel segments to be used for creating the continence mechanism and (if necessary) a reservoir obviously have to be made during surgery, depending on the degree and location of intra-abdominal adhesions and additional factors such as previous radiation damage to exposed bowel segments.

Own Results

Between 1990 and 2013, 1,313 patients underwent urinary diversion at our department with creation of continent reservoirs in 761 patients (58%). The most common indication for urinary diversion was bladder replacement after anterior exenteration for pelvic malignancies (81.2%).

Continent urinary diversion was performed as a primary surgical approach, in conversion procedures, and in salvage maneuvers after failure of previous reconstruction. Two hundred three patients underwent continent urinary diversion with an orthotopic ileocecal substitute, whereas 45 patients received a sigma rectum pouch.

In 511 patients, an ileocecal pouch with continent umbilical stoma (mean follow-up: 83.2 [range: 1 to 244 months]) was performed. As a continence mechanism, the submucosally embedded in situ appendix could be used in 225 cases. In 286 cases, an ileal intussusception nipple was established.

The submucosal tunnel was used for most ureteral implants (87%). Perioperative mortality was 0.8% in patients with continent diversion. Eleven major stoma-related complications were observed in patients with in situ appendix (4.9%), minor problems (outlet stenosis at skin level) occurred in 26 patients (11.6%). Forty-six patients with IIN (16.1%) required surgical revision of the nipple. All patients with umbilical stoma ($n = 511$; mean follow-up: 83.2 months)—including those with need of revisional surgery of the continence mechanism—finally were completely continent day and night with easy catheterization.

Ureterointestinal stenosis was encountered in 42 patients (8.2%). Early ureteral reimplantation was performed in most cases; nephrectomy was inevitable in eight patients due to a significant loss of renal function. Rupture of the continent reservoir occurred in six patients (1.1%) in all cases related to a blunt abdominal trauma. Whereas no pouch calculi were observed in the appendix group, stones in the reservoir had to be removed from eight patients (2.7%) with ileal nipple.

In 44 of the 511 patients (8.6%), the serum concentration of vitamin B_{12} had dropped below normal requiring vitamin B_{12} substitution. Mild hyperchloremic metabolic acidosis occurred in 19.5% of the patients requiring alkalizing medication.

In 18 patients with absent or dysfunctional lower urinary tract, a continent urinary reservoir has been created and renal transplantation was performed in a second stage (2). Within a mean follow-up of 89.2 months (ranging from 2 to 188 months), renal function remained stable in 15 patients, whereas 3 patients lost renal function 42, 62, and 109 months after transplantation. Two of these patients were excluded from the transplant program due to severe compliance problems.

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CHAPTER 83 ▪ URETEROSIGMOIDOSTOMY AND MAINZ POUCH II

MICHAEL RINK AND MARGIT FISCH

The first ureterocolonic anastomosis using the anus as continence mechanism was described over 160 years ago by John Simon of St. Thomas' Hospital for a child with ectopia vesicae (1). Since its first description, more than 60 modifications of ureterosigmoidostomy have been published (2). This technique was the method of choice for urinary diversion until the late 1950s, when electrolyte deterioration and secondary malignancies arising at the ureteral implantation site were observed (3,4). However, secondary malignancies, although to a lesser extent, were later also reported in other forms of urinary diversion (5). Critics of ureterosigmoidostomy tend to quote publications dealing with complications in patients treated prior to the 1950s (6). The development of new absorbable suture material, modern ureteric stents, antibiotics, and alkalinizing drugs served in solving many of the traditional shortcomings of ureterosigmoidostomy and have revitalized the interest in this technique.

A distinct drawback of ureterosigmoidostomy was frequency and urgency especially reported at night (3,7,8). Urodynamic investigations found that bowel contractions increased the pressure in the reservoir provoking incontinence (8,9). By interrupting the circular contractions (antimesenteric opening of the bowel and "reconfiguration"), low-pressure reservoirs can be constructed, thus improving continence rates and protecting the upper urinary tract by reducing the rates of reflux-related pyelonephritis (10). The era of low-pressure anal reservoirs began.

Kock et al. (9) were the first who applied these principles to ureterosigmoidostomy. Reports on similar techniques either augmenting the sigma with ileal (11) or ileocecal (12) segments followed. The sigma-rectum pouch (10,13) represents an equally effective but simpler operative procedure for creating a rectal low-pressure reservoir. The idea was initially described by Kocher in 1903 (14). R. Coffey (15) revolutionized the ureterointestinal anastomosis by inventing the physiologic submucosal tunnel, which also became the standard technique for ureteral implantation in classical ureterosigmoidostomy. However, in dilated or ureters with thick walls, this technique is associated with increased complication rates. Thus, for patients with these conditions, the ureteral implantation technique into an ileal neobladder published by Abol-Enein and Ghoneim (16,17) represents an alternative. This technique is also applicable for the sigma-rectum pouch (18). In the past decades, further modification of the original technique were described (19–21) underscoring the perpetual interest in this procedure. Nowadays, the techniques of low-pressure anal reservoirs have completely replaced classical ureterosigmoidostomy (2).

INDICATIONS

Indications for Surgery

The sigma-rectum pouch is suitable for primary urinary diversion, revision of ureterosigmoidostomy, and conversion of incontinent diversion. A major goal in patient counseling about urinary diversion is to determine the method, that is, the safest for the underlying disease (e.g., cancer control), has the fewest complications during short- and the long-term follow-up, and provides the easiest adjustment for patients' lifestyle, thereby supporting the best quality of life (QOL) (22). Hence, it is important to notice that adults, particularly elderly patients, often have problems adopting to a reservoir holding the urine with the anal sphincter, as they habitually used the urinary sphincter.

Nevertheless, the procedure is indicated in patients with actual or functional loss of the urinary bladder. The main indications were urinary diversion in patients with bladder exstrophy or after radical cystectomy for bladder cancer. The technique shows particularly good results in children that adjust well to anal reservoirs. Paramount to the success of anal sphincter–controlled urinary diversion is a competent anal sphincter mechanism. This is essential for the sigma-rectum pouch as well as for ureterosigmoidostomy.

Contraindications for Surgery

An absolute contraindication for rectosigmoid reservoirs is an incompetent anal sphincter. Inability of the patient to retain at least 400 mL in the upright position for 1 hour is a contraindication (22,23). Patients with neurogenic bladder dysfunction also have to be evaluated with caution because of the possible association of anal sphincter dysfunction (22). Another absolute contraindication is a preceding irradiation of the pelvis. In addition, rectosigmoid reservoirs are contraindicated in patients with diverticulosis of the sigmoid colon or polyposis.

Compromised renal function or chronic renal failure with serum creatinine levels above 1.5 to 2 mg/dL also represents a contraindication. In addition, severe hepatic dysfunction is a contraindication to continent diversion in general. Patients with compromised intestinal function, particularly inflammatory bowel disease, may benefit from an incontinent urinary diversion (22).

DIAGNOSIS

Preoperative Examinations

When a patient is considered for ureterosigmoidostomy or the sigma-rectum pouch, the anal sphincter function should be examined by a tap water enema (perianal instillation of 200 to 300 mL saline, which the patients should keep at least for 3 hours) as well as a rectodynamic investigation (exclusion of incontinence during measurement; anal sphincter profile: resting closure pressure >60 cm H_2O, closure pressure under stress >100 cm H_20). Bowel diseases such as polyposis or diverticulosis have to be excluded. To that end, bowel imaging with water-soluble contrast media should be performed preoperatively. In case of conspicuous findings, coloscopy is recommended for further diagnostics.

Patient Preparation

Nowadays, bowel preparation before urinary diversion is debatable particularly in ileal diversions. For elective colorectal surgery, mechanical bowel preparation has been practiced as a clinical routine for many decades. However, contemporary randomized clinical trials and meta-analyses found no strong evidence supporting the use of mechanical bowel preparation for elective colorectal surgery (24). Yet, the authors of this chapter recommend some type of bowel preparation prior to elective colonic surgery to reduce the stool burden. This may facilitate surgery and potentially avoid postoperative complications.

Broad-spectrum antibiotics such as cephalosporins combined with metronidazole are administered perioperatively. Alternatively, piperacillin sodium combined with an aminoglycoside can be given at the beginning of surgery. A gastric tube (occasional alternative: gastrostomy) and a rectal tube are placed. For parenteral nutrition, a central venous catheter is placed.

ALTERNATIVE THERAPY

Alternatives to the sigmoid-rectal pouch are any other forms of urinary diversion, including bladder substitution, continent cutaneous urinary diversion, and conduit diversion.

SURGICAL TECHNIQUE

Classical Ureterosigmoidostomy

After a median laparotomy, the peritoneum is incised lateral to the descending colon and the left ureter is identified. A peritoneal incision is made on the contralateral side lateral to the ascending colon and the right ureter identified. Both ureters are dissected, respecting the longitudinal vessels running inside the Waldeyer sheet. The dissection is extended caudally to the ureterovesical junction. The ureters are cut as distal as possible, and stay sutures are placed at the 6 o’clock position. The ureteral stumps are ligated.

The colon is slightly elevated at the rectosigmoid junction by four stay sutures. After opening of the sigmoid colon over a length of 4 cm by an incision of the anterior teniae, four mucosal stay sutures are placed in the mucosa of the posterior aspect of the sigmoid (Fig. 83.1). The bowel mucosa is incised between the proximal stay sutures, and a buttonhole type of excision of posterior bowel wall is performed. A straight or slightly curved clamp is advanced through the opening, and a tunnel is created by blunt dissection below the visceral peritoneum of the mesosigmoid (Fig. 83.2). The ureter is pulled into the lumen of the intestine. After creation of a submucosal tunnel of about 3 cm in length, the ureter is threaded through this tunnel, avoiding torsion of the ureter (Fig. 83.3). The anterior wall of the ureter is spatulated for a length of 1 cm (Fig. 83.4A). For the ureterointestinal anastomosis, an anchor suture is placed at the 6 o’clock position grasping intestinal mucosa and musculature (5-0 polyglactin), and the anastomosis is completed by several ureteromucosal single stitches (6-0 polyglactin). A 6Fr silastic stent is inserted into the ureter and fixed to the mucosa by a polyglactin rapide 4-0 suture (Fig. 83.4B). The contralateral ureter is implanted about 3 cm lateral and either proximal or distal to the first anastomosis using the same technique (Fig. 83.5). The ureteral stents are inserted into the rectal tube and pulled out through the anus. Thereafter, the rectal tube is reinserted.

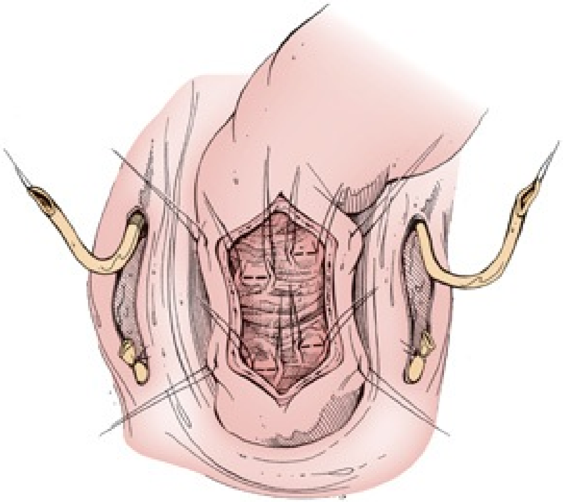

FIGURE 83.1 Open transcolonic ureterosigmoidostomy: Both ureters have been cut at its entrance into the bladder and mobilized. The site of the planned ureteral implantations in the posterior sigmoid wall are outlined by stay sutures.

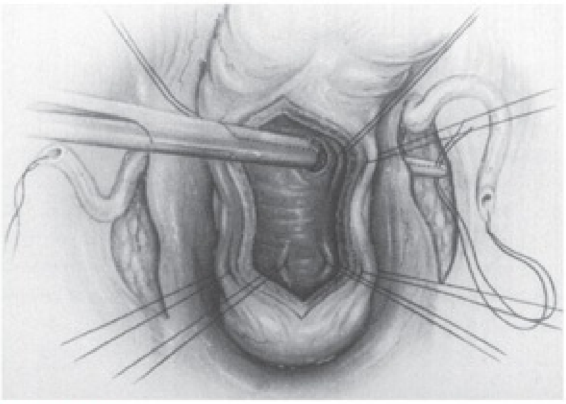

FIGURE 83.2 After incision of the mucosa and excision of a buttonhole type of excision of the posterior bowel wall site, the ureter is brought through the intestinal wall; a subperitoneal tunnel is modelled bluntly from this point to the left incision in the peritoneum. The curved clamp is advanced precisely below the peritoneum.

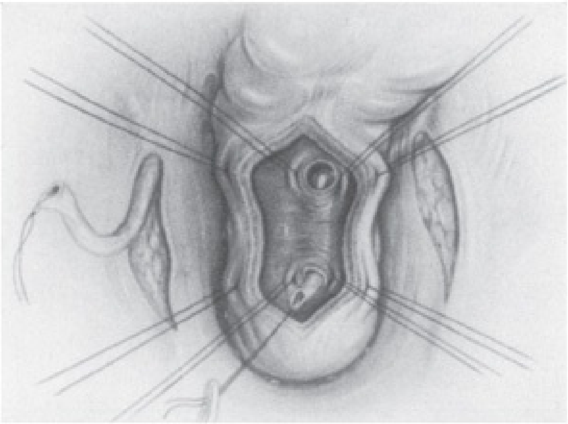

FIGURE 83.3 The ureter has been pulled into the bowel and through a submucous tunnel reaching from the proximal to the distal stay suture.

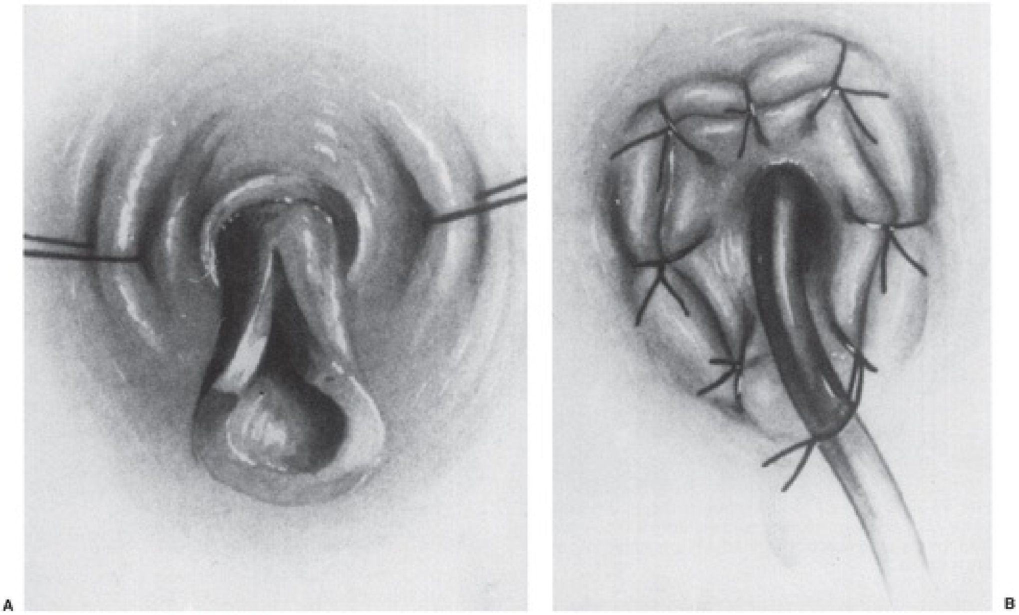

FIGURE 83.4 Spatulation of the anterior wall of the ureter (A) and ureteromucosal anastomosis between ureter and intestinal wall. The ureter is stented (B).

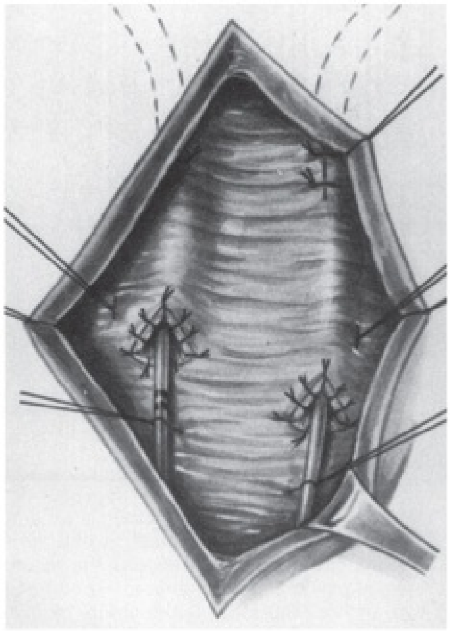

FIGURE 83.5 Identical implantation of the right ureter 3 cm lateral and proximal or distal of the first anastomosis.

The anterior sigmoid colon is closed in one layer using interrupted sutures of 4-0 polyglactin or in two layers using running sutures (5-0 polyglactin for the mucosa and 4-0 polyglactin for the seromuscularis). The peritoneal incisions are closed. At the end of the operation, separate fixations of the rectal tube and ureteral stents to the skin of the anus are performed (nonabsorbable material).

Sigmoid-Rectal Pouch (Mainz Pouch II)

Access is gained by a median laparotomy as for ureterosigmoidostomy. The rectosigmoid junction is identified and two stay sutures are placed. The peritoneum is incised lateral to the descending colon and the left ureter is identified. Another perineal incision is made lateral to the ascending colon and the right ureter is identified. Both ureters are dissected down to the ureterovesical junction, respecting the longitudinal vessels running inside the Waldeyer sheet. The ureters are cut as distal as possible, stay sutures are placed at the 6 o’clock position, and the ureteral stumps are ligated.

For creation of the pouch, the intestine is opened at the anterior tenia starting from the rectosigmoid junction over a total length of 20 to 24 cm distal and proximal of this point (Fig. 83.6). By placing two stay sutures in the middle of the incision at the right side of the opened rectosigmoid, the intestine is positioned in a shape of an inverted U. The posterior wall of the pouch is closed by side-to-side anastomosis of the medial margins of the U using two-layer running sutures of 4-0 polyglactin for the seromuscular layer and 5-0 polyglactin for the mucosa (Fig. 83.7).

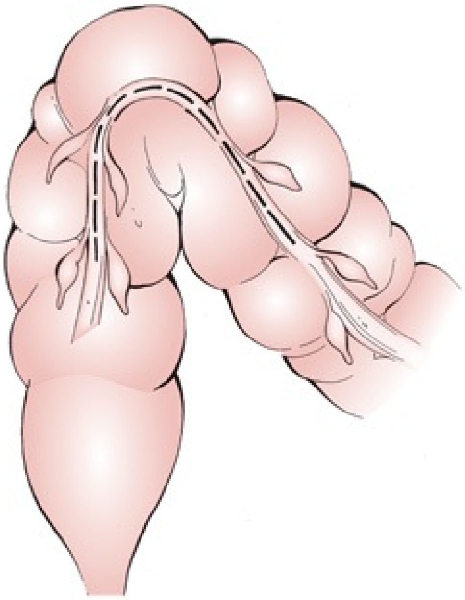

FIGURE 83.6 Sigmoid-rectal pouch (Mainz pouch II). Identification of the rectosigmoid junction.

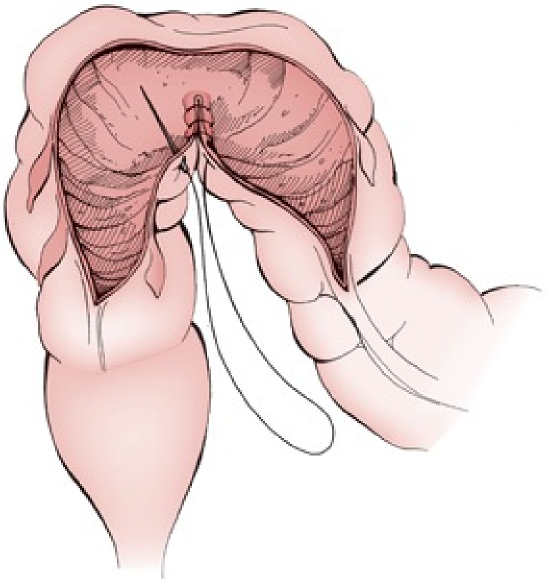

FIGURE 83.7 Opening of the rectosigmoid at the anterior tenia starting from the rectosigmoid junction over a total length of 20 to 24 cm distal and proximal of this point. Side-to-side anastomosis of the medial margins of the cut bowel edges by two-layer closure using running sutures of absorbable synthetic suture material (4-0 for the seromuscular layer and 5-0 for the mucosa).

The left ureter is pulled through retromesenterically above the inferior mesenteric artery from the left to the right side (Fig. 83.8). For ureteral implantation, four mucosal stay sutures are placed parallel right and left to the medial running suture. The mucosa is incised, and the seromuscular layer is excised between the two cranial stay sutures to create a wide buttonhole type of opening as an entrance of the ureter into the pouch. The dissection of the submucous tunnel starts from this incision downward over a length of 2.0 to 2.5 cm. The mucosa is incised at the distal end of the tunnel and the ureter is pulled into the tunnel. After having resected the ureter to an adequate length, implantation is completed by placing an anchor suture at the 6 o’clock position (5-0 polyglactin) and several interrupted ureteromucosal sutures (6-0 polyglactin). The cranial mucosal incision is closed by a running suture with polyglactin 4-0, which has a short reabsorption time. The contralateral ureter is implanted in the same manner (Fig. 83.9).

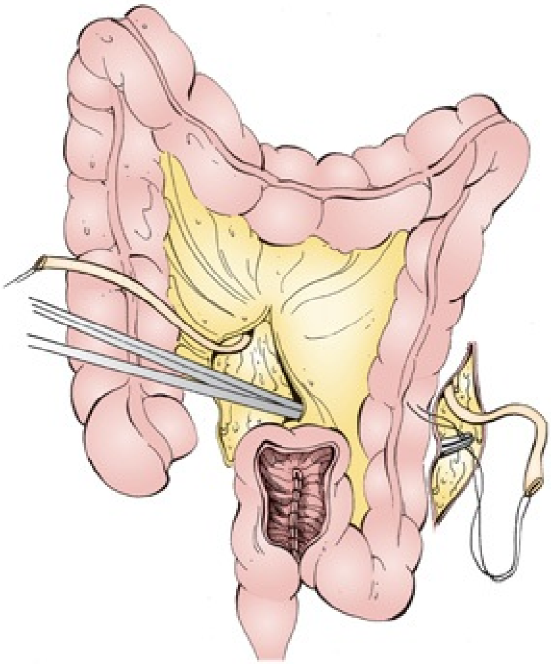

FIGURE 83.8 The left ureter is pulled through retromesenterically to the right side.

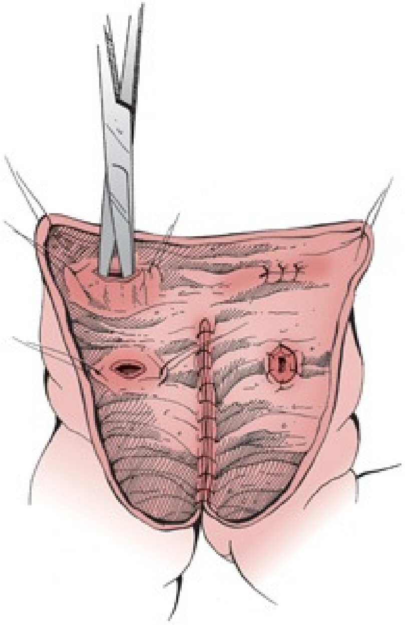

FIGURE 83.9 Creation of a wide buttonhole as an entrance of the ureter into the pouch and preparation of a submucous tunnel (2 to 2.5 cm in length). Incision of the mucosa at its distant end and pull-through of the ureter. Ureteral implantation by two anchor sutures at the 5 and 7 o'clock position and single-stitch mucomucous sutures. Closure of the cranial mucosal incision by a running suture with 6-0 absorbable synthetic suture material.

Next, 6Fr ureteral stents are inserted into the ureters and are pulled out through the anus with the rectal tube, which is afterward reinserted. The pouch is fixed to the anterior longitudinal band at the sacral promontory in the region of the proximal end of the posterior medial running sutures by two Bassini sutures of 3-0 nonabsorbable suture material (Fig. 83.10). Closure of the anterior pouch wall is performed in two-layer sutures (5-0 polyglactin for the seromuscular and 4-0 polyglactin for the mucosal layer). Alternatively, single-layer closure using locked running suture (Fig. 83.11) or interrupted stitches can be used. The peritoneal incisions are closed and the anastomotic site of the pouch is covered by omentum. The rectal tube and the ureteral stents are separately fixed to the skin of the anus (nonabsorbable material).

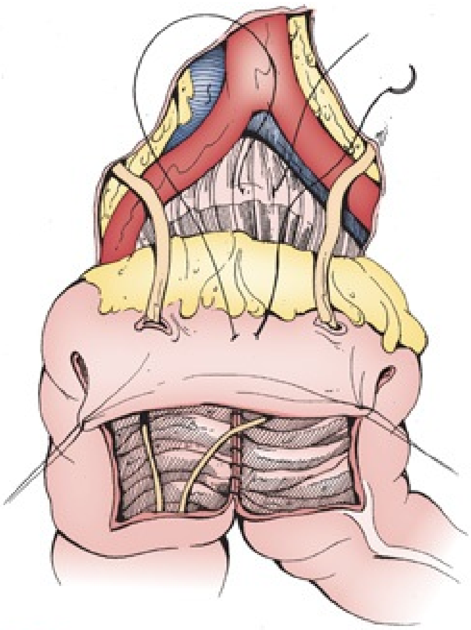

FIGURE 83.10 After a 6Fr stent is placed in each ureter, which are pulled out through the anus with the rectal tube, the pouch is fixed to the anterior longitudinal band of the spine (promontory) in the region of the proximal end of the posterior medial running sutures by two Bassini sutures.

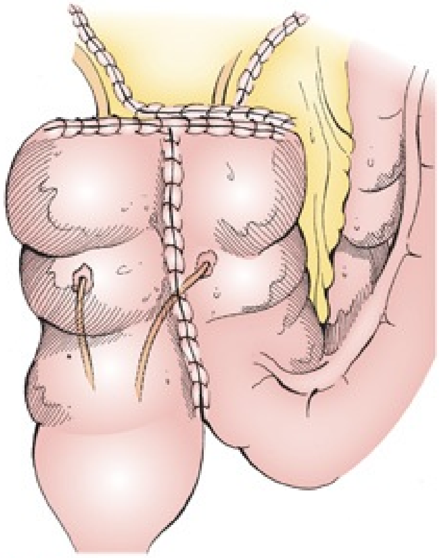

FIGURE 83.11 Closure of the anterior pouch wall by seromuscular single stitches with 4-0 absorbable synthetic suture material. Closure of the peritoneal incisions.

Serosa-Lined Extramural Tunnel Ureteral Implantation

Mobilization of the bowel includes the left colonic flexure (in cases of a short sigmoid segment). Dissection of the ureters is identical to the standard technique (Fig. 83.12). An S-shaped sigmoid segment is outlined by stay sutures, with each limb of 10- to 12-cm length, resulting in a total length of 30 to 36 cm (Fig. 83.13). After antimesenteric opening of the S-shaped sigmoid colon (Fig. 83.14) in the area of the anterior tenia, a side-to-side adaptation of the seromuscularis of both limbs is obtained by single-stitch sutures close to the mesentery (nonabsorbable suture), thereby creating two serosa-lined channels.

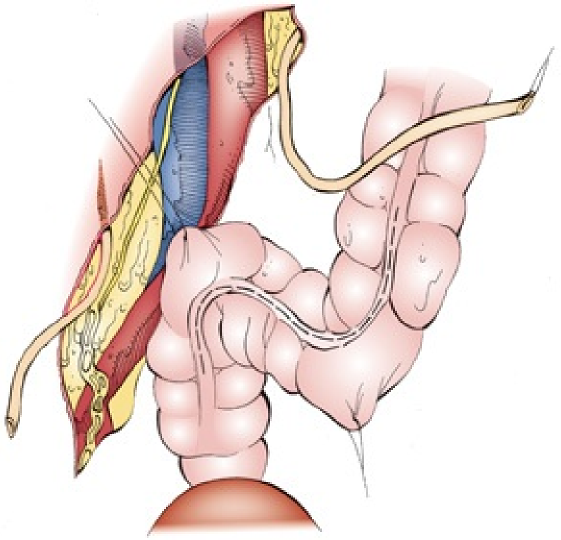

FIGURE 83.12 Ureteral implantation into a sigma-rectum pouch via a serous-lined extramural tunnel. Right and left paracolonic incision; identification and dissection of the ureters.

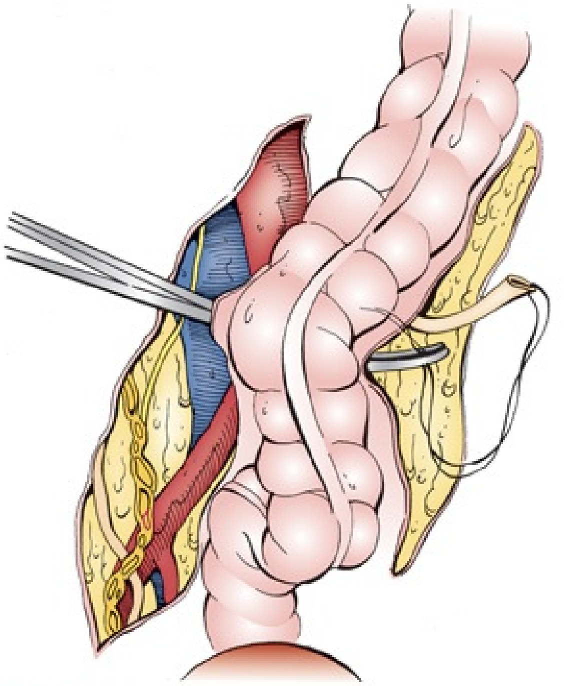

FIGURE 83.13 An S-shaped sigmoid segment is outlined by stay sutures. The length of each segment is 10 to 12 cm, starting at the rectosigmoid junction (= standard technique), adding another segment of 10 to 12 cm of the ascending colon.

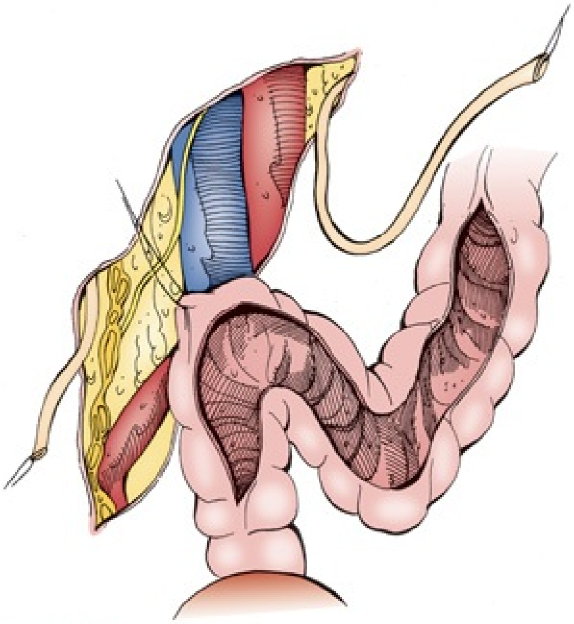

FIGURE 83.14 The marked segment is opened in the area of the anterior taenia. Excision of a mesenteric window for pull-through of the left ureter.

On the right side, an entrance for the right ureter is created at the cranial aspect of the running suture. The mesentery cranial to the left running suture is incised and the left ureter pulled through. The ureters are placed in their respective channels (Fig. 83.15), and the cut edges of the bowel are sutured above the ureter with a running suture incorporating all layers, thus converting the channel into a tunnel. The length of the tunnel should be four times the diameter of the ureter. For implantation, the ureter is cut at its required length and spatulated. Four anchor sutures are placed at the 11 and 1 o'clock and the 5 and 7 o'clock positions through all layers of the ureter as well as all layers of the bowel wall (4-0 polyglactin). Ureteromucosal sutures are placed in between the anchor sutures to complete the anastomosis (5-0 polyglactin) (Fig. 83.16). Two ureteral stents are inserted and pulled out through the anus with the rectal tube after having been fixed to the bowel mucosa (4-0 polyglactin rapide). The anterior pouch wall is closed by interrupted seromuscular sutures (4-0 polyglactin) (Fig. 83.17).

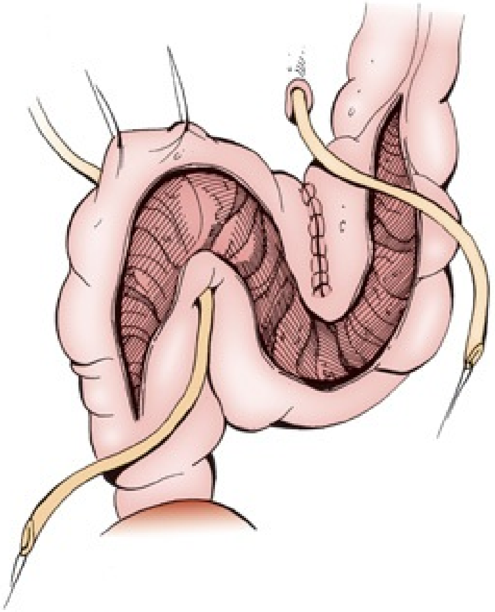

FIGURE 83.15 Side-to-side adaptation of the seromuscularis of the limbs of the S by two interrupted sutures close to the mesentery (4-0 nonabsorbable suture), thereby creating two serous-lined channels. On the right side, an entrance for the right ureter is left at the cranial aspect of the running suture and the ureter is pulled through. One ureter is placed in each channel created between the segments of the S.

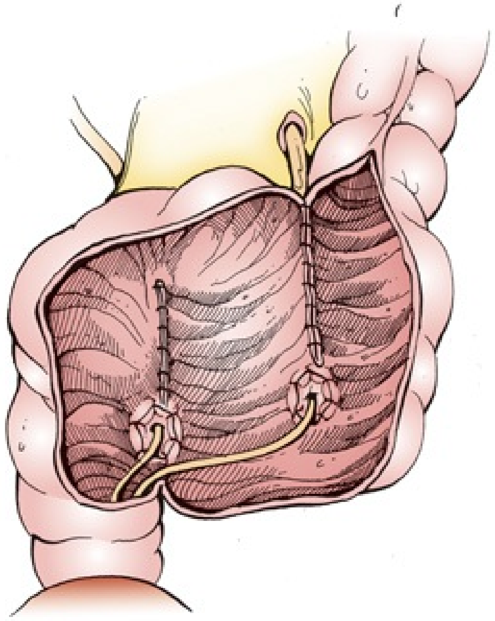

FIGURE 83.16 Ureteral implantation in the area of the continuous suture line. Insertion of ureteral stents.

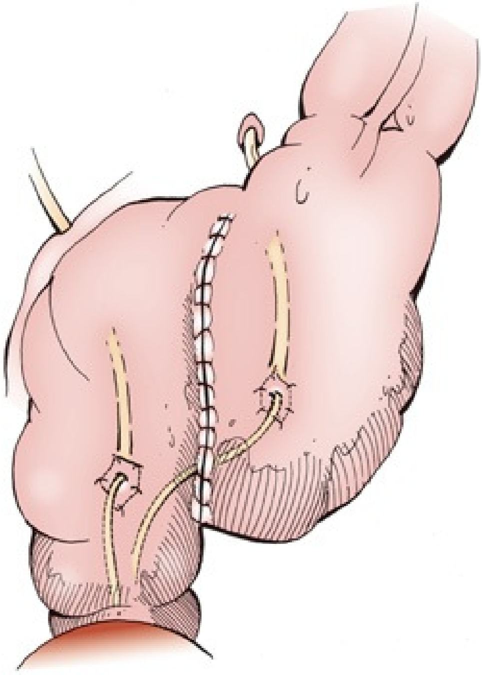

FIGURE 83.17 The stents are pulled through the anus and the pouch is closed.

Surgical Tricks (Sigmoid-Rectal Pouch)

When the anastomosis reaches deep down to the rectum, it is easier to suture the pouch starting caudally, as the deepest point of the anastomosis is the most critical part and can be reached more easily at the beginning of the anastomosis. To facilitate fixation of the pouch to the promontory, one sutured end of the dorsal running suture can be pulled through dorsally outside of the pouch and be tightened with the fixation suture placed in the anterior band at the promontory. A Bassini needle facilitates placement of the fixation suture through the anterior band of the spine. During ureteral implantation, sufficient spatulation of the ureters is of utmost importance to avoid a nipple-like protrusion of the ureters.

To drain an incidental hematoma of the submucous tunnel, the mucosa covering the tunnel can be selectively incised at different points. The S-shaped sigmoid-rectal pouch as created for the ureteral implantation via a serosa-lined tunnel has an ideal and stable position within the pelvis; therefore, no fixation to the promontory is needed.

OUTCOMES

Low-pressure rectal reservoirs have replaced classical ureterosigmoidostomy (10). The technique is excellent for continent diversion particularly in women and has gained widespread acceptance in countries in which catheter material or stoma bags are difficult to obtain or do not find patient acceptance (19,21,25,26). Another indication is bladder exstrophy, especially in those patients in whom bladder reconstruction has failed (25,27).

An adequate patient selection is of utmost importance for outcomes. Most important is a competent anal sphincter mechanism. However, other technical details such as ureteral implantation, side-to-side anastomosis by two layers, and the fixation at the promontory (classical technique) are further improvements that are associated with more favorable outcomes.

Meanwhile, several groups have published long-term outcomes and complication rates (28–31). Comparability of the different report regarding outcomes is difficult due to the distinct techniques. Overall, results of ureterosigmoidostomy and the sigmoid-rectal pouch are reasonable. However, some specific issues have to be considered during follow-up and patient counseling regarding these techniques.

Development of Colorectal Carcinoma

Secondary malignancies (i.e., colorectal carcinoma) particularly at the position of ureteral implantation in the sigma or rectum are common finding during long-term follow-up (5). The risk of colorectal carcinoma development was increased 0 to 42 times in different reports (29,31–34). In some reports with small patient series, no colorectal malignancies were observed in patients treated with ureterosigmoidostomy (31,33). Similar findings were reported for 38 children who underwent Mainz pouch II urinary diversion and had a follow-up of more than 10 years receiving annual rectosigmoidoscopy (28). In contrast, a collaborative report from 44 German urologic departments comprising 17,758 urinary diversions found the tumor risk in ureterosigmoidostomies was 22-fold higher than in other continent forms of urinary diversion such as neobladders or pouches (34). A recent Swedish study reported on 24 patients with half century of follow-up in which ureterosigmoidostomy was performed in early childhood (29). Of the 24 patients, 7 developed invasive colorectal adenocarcinoma with 6 of those being low differentiated. One additional patient experienced colorectal adenocarcinoma in situ.

In conclusion, due to the significantly increased risk of a secondary malignancy in these types of urinary diversion, an annual lifelong surveillance with rectoscopy starting from the fifth postoperative year is mandatory.

Continence Rates

Both, ureterosigmoidostomy and the Mainz pouch II, are associated with very good day and nighttime continence rates. In the literature, the overall continence rates for rectal reservoirs are approximately 95% (30,31). The majority of studies found patients continent during the daytime with an emptying frequency of three to five times (25,28). Although complete continence during the night is reported in some studies (25), the majority of studies report nighttime incontinence requiring pads in about 10% to 20% of patients (28). About one-third of the patients have to urinate more than six times during the day and more than three times during the night (35). It has been suggested that the risk of severe nocturnal incontinence may be higher in patients after revision surgery for their rectal reservoir (36).

Upper Urinary Tract Safety

In general, upper urinary tract outcomes after ureterosigmoidostomy and Mainz pouch II urinary diversions are reasonable. Indeed, it is difficult to make a point on the true impact of these diversion types on upper urinary tract outcomes, as all studies analyzing this issue were retrospective. In addition, differences regarding age, follow-up, additional underlying conditions, such as diabetes and hypertension with increased risk for renal deterioration, and pre- and postoperative techniques and routines might affect study outcomes. Another problem relates to the methods of measuring renal function after urinary diversion. Most reports have relied on serum creatinine and intravenous pyelography (IVP), but both are imprecise for this purpose.

In the published literature, a wide range of upper urinary tract function is reported. Some investigators found a normal urinary tract function with creatinine levels within normal limits (28) or reported on improved or stabilized renal function in the majority of renal units (64/66 RUs) (25), respectively. In contrast, other found impaired renal function ranging from 3% to 40% (31,37), although definitions for impaired renal function vary between reports. Frequently observed upper tract complications, which may be associated with subsequent renal impairment, include acute pyelonephritis (~16%), obstructive uropathy (~10%), recurrent urinary tract infections (mainly due to reflux [~4%]), and development of renal stones, respectively (38). In addition, metabolic acidosis is a common finding in these patients, which may be promoted by renal impairment (28,38–41).

In summary, upper urinary tract impairment may occur to a certain degree after rectal reservoir urinary diversion during long-term follow-up. Therefore, we recommend periodic follow-up examinations to check the upper urinary tract and prevent metabolic deterioration (28).

Quality of Life

Concerning quality of life, the Mainz pouch II serves as a satisfying continent urinary diversion for both sexes. No statistically significant differences in functional and symptom scales or global health status were detected between males and females. All scales but diarrhea showed good results, and the outcome was comparable to health-related quality of life in a reference population (35).

COMPLICATIONS

There are some specific complications that frequently occurred during short- and long-term follow-up of rectal reservoir patients. Early and late complications are reported in approximately 10% of patients (31,39) and 40% of patients (31), respectively.

A repeat surgical intervention is a common finding in patients with rectal reservoirs. In contemporary reports, reoperation rates are mentioned in up to 37% (31), although lower rates are reported from tertiary care centers. Different reasons are responsible for these high reintervention rates: Reimplantation of the ureter is a common indication (14.4%) in these patients, with ureterointestinal stenosis being a more common indication (10.1%) than reflux (4.3%) (28). In addition, conversion to different forms of urinary diversions during long-term follow-up has been reported in a significant number of patients (48%) in some studies (37).

As mentioned earlier, the foremost complication is stenosis at the ureterointestinal anastomosis. The incidence ranges from 10% to 22% (28,31). Hadzi-Djokic and Basic (41) reported a stenosis in 11 out of 220 patients. Hammouda et al. (42) used the serosa-lined extramural tunnel as well as the submucosal tunnel for ureteral implantation in 95 patients and found reflux in 1.6% of RUs and stenosis in 5.3%, respectively. Balloon dilatation and endoscopic incision of the stenosis have been described to treat ureterointestinal anastomosis, however, we would recommend open revision with ureter reimplantation, which offers reliable results for successful treatment (40).

Pyelonephritis is described with an incidence of 3% to 16% and should be treated with antibiotics (31,36,39,41). Only those patients with recurrent pyelonephritis and a decrease in split renal function require ureteral reimplantation.

About two-thirds of patients will develop an acidosis with a negative base excess. Early correction (starting from a base excess of –2.5) with alkali supplementation is recommended to avoid further complications, especially in children.

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CHAPTER 84 PALLIATIVE URINARY DIVERSION

STEPHAN DEGENER, BURKHARD UBRIG, AND STEPHAN ROTH

The word *palliative* derives from the Latin *palliare*, which means "to cover with a coat." The term *palliative therapy* implies the impossibility of cure. The main goal of palliative urinary diversion is the control or the prevention of symptoms caused by incurable diseases of the urinary tract, usually cancer. In addition to bladder and prostate cancer, advanced cervical, ovarian, breast, or colorectal cancer may interfere with the urinary tract.

INDICATIONS FOR SURGERY

There are no prospective studies that compare bladder-preserving strategies and palliative cystectomy in locally advanced bladder cancer. However, the clinical course of patients with advanced muscle-infiltrating bladder cancer under a bladder-preserving strategy is often dismal. In one study, 24 patients with muscle-infiltrating bladder tumor not eligible for cystectomy (mean age 81 years) were treated with bladder preservation for a mean 22.6 months. All complained of frequency, urgency, and severe nocturia. The mean hospital readmission rate was 8 times per patient. Salvage cystectomy was required in 11 of 24 cases, in 7 solely because of recurrent macrohematuria. Major complications that might have been prevented with early cystectomy were ileus in three cases and an enterovesical fistula in one. All patients in whom the bladder was preserved complained of severe symptoms that reduced the quality of their remaining life (1).

Therefore, in most palliative patients with locally advanced pelvic cancer, cystectomy or complete pelvic exenteration is the standard option, unless it is a nonresectable tumor. There is some evidence that radical cystectomy itself, if performed efficiently and with minimal blood loss, does not decisively increase the morbidity of the palliative urinary diversion. By contrast, the high disease-related complication rate with explicit impairment of the remaining life span has to be considered in conservative strategy (1–3).

In a specific group of patients with high surgical risk, frozen pelvis, or a short residual life expectancy, supravesical diversion without exenteration may be a viable option that results in good symptom control (3). Indications are infrequent, and results of this strategy have rarely been reported. Further alternatives to radical cystectomy with urinary diversion are observation, repeated transfusions, or indwelling catheters depending on the underlying disease process.

Nevertheless, the decision will be made in individual cases by the urologic surgeon and the patient. Despite all surgical and anesthesiologic advances in some borderline cases, the risk of the surgical approach is considered too high. The American Society of Anesthesiologists (ASA) score has been described as one reliable decision criterion: ASA scores ≥3 is significantly associated with increased complication and reoperation rate, especially those related to the type of urinary diversion (4).

SURGICAL TECHNIQUE AND OUTCOMES

Palliative urinary diversion will usually be performed with the lowest risk options that are acceptable to the patient. In general, conduits will often be preferred in palliative situations. Some patients for whom palliation is the goal may be very poor surgical candidates. Therefore, in these cases, less elaborate techniques such as cutaneous ureterostomy can be a safe and simple alternative. Nephrostomy placement should be considered in patients with extreme anesthetic or perioperative risks and in end-of-life situations.

Ileal Conduit

Assuming adequate surgical risk and life expectancy, an ileal conduit is the first choice of many urologists in a palliative situation. Ileal conduit can be performed despite previous abdominal surgery (e.g., enterostomy) in cases of impaired renal function and in patients with limited compliance because ostomy care is relatively easy. Patients may return to normal activity soon after discharge (Fig. 84.1). Postoperative complications such as metabolic acidosis or ureteroenteric anastomotic stenosis are extremely rare, and increasing conduit-related complication rates are only seen in long-term survivors (5).

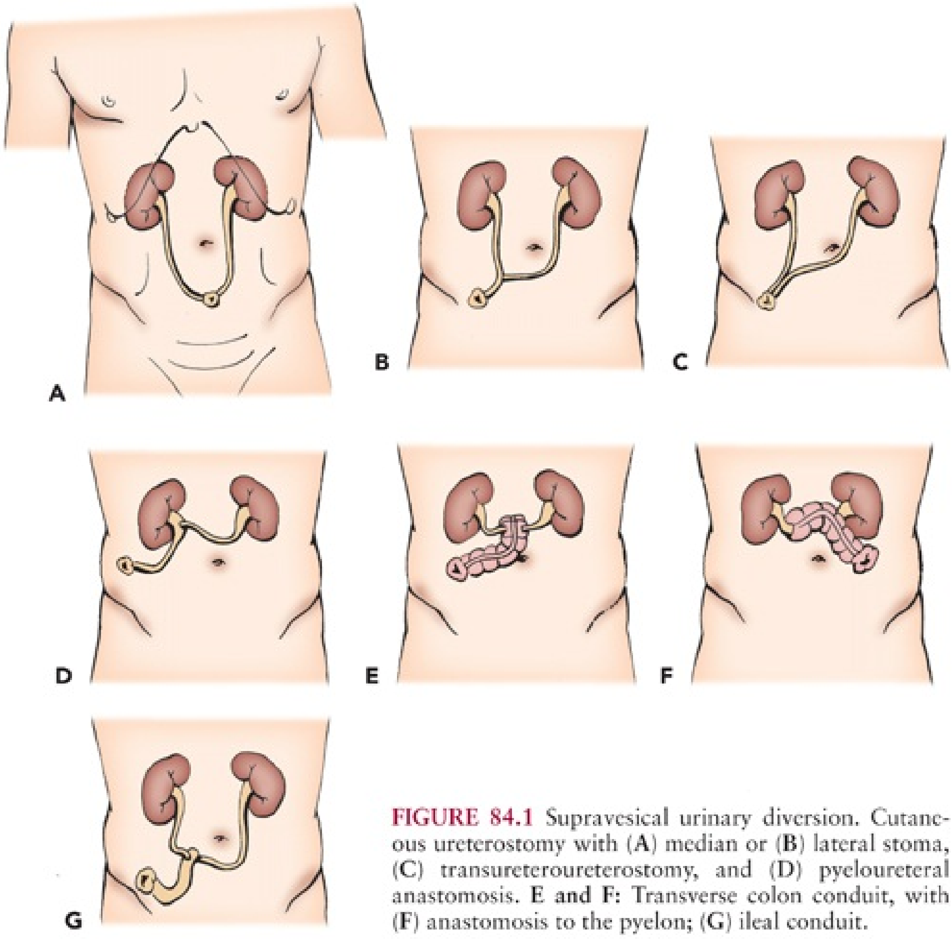

FIGURE 84.1 Supravesical urinary diversion. Cutaneous ureterostomy with (A) median or (B) lateral stoma, (C) transureteroureterostomy, and (D) pyeloureteral anastomosis. E and F: Transverse colon conduit, with (F) anastomosis to the pyelon; (G) ileal conduit.

An ileal conduit should not be used in patients with short bowel syndrome, inflammatory small bowel disease, or in those who have had high-dose radiation to the ileum. The small intestine and ureters are usually within the radiation portals for treatment of pelvic malignancy which may cause long-term sequelae: impaired postirradiation healing of gut anastomosis, and scarring with stricture formation of the ureterointestinal anastomosis may occur. Strategies to prevent strictures are high ureter resection, prolonged anastomotic single-J ureteral stenting, and preservation of paraureteric blood supply with minimal use of electrocautery.

Sigmoid Colon Conduit

The sigmoid colon is a viable alternative to the ileum if the latter cannot be used for conduit construction (see earlier). However, it should not be used if it is diseased, has been exposed to radiation, or if the internal iliac arteries have been embolized (or ligated) with the rectum still in place. This last condition might lead to rectal sloughing because of compromised rectal blood supply (6). The stoma will usually be placed in the lower left abdominal quadrant (see Fig. 84.1).

Transverse Colon Conduit

In patients irradiated for urologic, gynecologic or intestinal malignancies, the use of the ileum and lower colon segments is associated with a higher early and late complication rate. In these cases, a transverse conduit can be indicated because this part of the colon is not within the common radiation portals (avoidance principle). The blood supply via the middle colic artery is usually ample. Indications for the use of transverse colon for conduit construction can be marked radiation fibrosis of the ureters or impaired ureteral mobilization because of frozen pelvis or periureteral lymph nodes. The ureterointestinal anastomosis can be accomplished with very short ureteral stumps. Also, anastomosis with the renal pelvis is feasible (see Fig. 84.1). The perioperative mortality rate has been reported at 3% (6).

Bilateral Cutaneous Ureterostomy with Single Stoma

In patients for whom major gut surgery is not advisable, cutaneous ureterostomy is a safe and simple alternative to transintestinal diversion (see Fig. 84.1); operative time is short, and renal function is not a selection factor, although the most common complication of all intestinal urinary diversion, mechanical or paralytic ileus, rarely occurs. A single stoma construction in the lateral or midline position is generally feasible and ensures easier care with minimal discomfort in patients without excessive obesity, extensive paraureteral lymph node involvement, previous radiation therapy, or frozen pelvis (3).

Ureterocutaneostomic Stomal Construction

Stomal construction is of critical importance. Stoma stenosis is the major problem with all forms of ureterocutaneostomies, although recent data show significantly better tube free rates of up to 80% to 100%. Stomal stenosis mainly results from ischemia of the distal ureteral end with consequent sloughing and fibrosis. Different strategies like an omentum wrapping or the preservation of the fascia between the spermatic cords and the ureters (2,7) have been described to prevent ischemia. Additionally, distal spatulation of the ureteral end and plastic augmentation with a V-shaped skin flap as proposed by Rodeck (8) or the split-cuff nipple should be considered. Therefore, the ureter is spatulated, folded back to form split-cuff nipple, and corners are sewn with small gap to prevent ureteral constriction (9).

To prevent ureteral obstruction Rodríguez et al. (10). reported a postoperative stent placement for at least 3 months with obstruction in only 4.5%. Also, postoperative tension or hyperplastic epithelium at the ureterocutaneous anastomosis may also play a role in luminal constriction. Firm fixation of the anastomosis to the skin and healing by first intention is essential. The following technique has been proposed. Both ureters are guided to the skin and anastomosed with each other and the stomal skin (see Fig. 84.1). This can be done by passing one ureter to the contralateral side through the retroperitoneum and behind the descending colon (2). Alternatively, in slender patients, the ureters may be mobilized completely extraperitoneally, led around the peritoneal sac, and conjoined in the midline. An infraumbilical stoma can then be formed (3).

Transureteral Cutaneous Ureterostomy

One ureter is retroperitoneally led to the other side and anastomosed to the contralateral ureter end to side (e.g., with 5-0 Monocryl). This technique is particularly well suited in patients with one dilated ureter. Thus, the nondilated ureter is implanted into the dilated one which will be guided through the abdominal wall and anastomosed to the skin.

Transureteropyelocutaneous Ureterostomy

Alternatively, the collecting systems of both renal units can be connected via a high ureteral or pyeloureteral anastomosis (see Fig. 84.1). The operative mortality is 1.75%; severe late complications occur in 10.5% of cases. The most frequent problems (14%) arise from the nephrostomy (dislocation, pyelonephritic episodes, and urine leakage) and from stenosis of the ureteropelvic or ureteral anastomosis (10%) (11).

Percutaneous Nephrostomy

Percutaneous nephrostomy is another alternative for supravesical diversion. The advantages are the relative ease with which these can be placed under local anesthesia, but the drawbacks are the need for continuous replacement owing to encrustation as well as the propensity for these to become dislodged. Bilateral nephrostomies are sometimes badly tolerated, and usually only the kidney with better function should be diverted by nephrostomy. To prevent discomfort for the patients, the nephrostomy should be positioned as lateral as possible. For the balloon filling, a concentration equivalent to 5% saline is recommendable. Additionally, displacement can be prevented efficiently by using nephrostomies with a locked tie or other attachment devices. However, recent data show that nephrostomy diversion is associated with no significant difference in the quality of life but can improve the chance of survival in the short term (12).

In rare cases of further ureteral urine flow, additional occlusion of the ureter may sometimes be necessary. Transection and ligation of the ureter with nonabsorbable material may be performed. This may be accomplished by a small flank incision or laparoscopically. If feasible, a unilateral cutaneous ureterostomy may be the better alternative in such cases.

Several percutaneous techniques to obliterate the ureteral lumen have been proposed, with poor long-term results: butyl-2-cyanoacrylate, detachable balloons, liquid polyacrylonitrile, electrocautery, nylon and silicone occlusion devices, coil embolization by interventional radiology, and nephrostomy devices for transient closure of the ureteral lumen did not survive the test of time.

Eliminating Function of the Contralateral Kidney

If only one kidney is diverted, and urine continues to flow downstream from the contralateral kidney, it may be necessary to render the latter nonfunctional. Some palliative patients are poor candidates for nephrectomy. Ligature and transection of the ureter will usually result in long-term success in a previously obstructed hydronephrotic kidney with significant parenchymal reduction. Postinterventional paralytic ileus and some pain may be expected during the first postoperative days.

However, in unobstructed kidneys, ligature of the ureter should not be done because of significant pain and spontaneous ureteral recanalization. Usually, renal arterial embolization will be considered. Since the first description in 1969 by Lalli et al., (13) there have been only a few case series published. Excellent results to stop urine production from the kidney have been reported in cases of transcatheter ablation, with a mixture of ethanol and contrast agent and a combination of sponge and coil plugging of the proximal artery: Of 20 patients, urinary flow ceased after 2 days in 18 patients, 2 required a second session. The authors proposed epidural anesthesia, which may also be used in the first 2 postoperative days for pain control. Transient postinterventional paralytic ileus and fever may be expected. Other reports show good symptom control and low complication rates (14,15).

PALLIATIVE TREATMENT OF URETERAL OBSTRUCTION

Common causes of malignant compression of the ureterovesical junction and the prevesical ureter are bladder, prostate, and cervical cancers. Malignant obstruction of the mid- or upper ureter is usually caused by metastatic lymphatic spread, such as from metastatic breast cancer, lymphatic disease, colon cancer, and cancers of the female internal genitalia. However, even years after radiation therapy, newly arising ureteral obstruction, rather than tumor recurrence, may represent a long-term sequelae of radiation.

Indications for treatment should be considered very carefully. Septic episodes, with accompanying persistent pain, are rare in malignant ureteral obstruction if there has been no retrograde endoscopic manipulation. The insertion of a regular double-J stent or a nephrostomy will result in repeated consultations to change the catheters, sometimes under general anesthesia. Any measure carries the risk of infection or dislocation. Many patients are in critical condition, and the quality of life should be the main treatment goal.

In patients with unilateral ureteral obstruction and sufficient function of the contralateral kidney, one should generally abstain from therapy; however, if nephrotoxic chemotherapy is planned, or life expectancy exceeds 1 to 2 years, intervention may be indicated. In patients with bilateral ureteral obstruction and impending renal failure, it is usually sufficient to stent, divert, or bypass only one renal unit (usually the one with better function). The use of the techniques mentioned in the following text assumes normal bladder function. Otherwise, supravesical diversion may be considered.

Retrograde stenting with replaceable double-J stents is often considered the first-line option for relieving ureteral obstruction (Fig. 84.2). Transurethral resection will sometimes be necessary to find the ureteral orifice or intramural ureter hidden in the tumor. In these situations, prior antegrade placement of a guide wire or antegrade placement of the stent itself may be very useful. Specific drawbacks of double-J stents are irritative bladder symptoms, stent obstruction, and encrustation—necessitating repeated changes (intervals range from 6 weeks to 6 months but can be much shorter)—and stent migration.

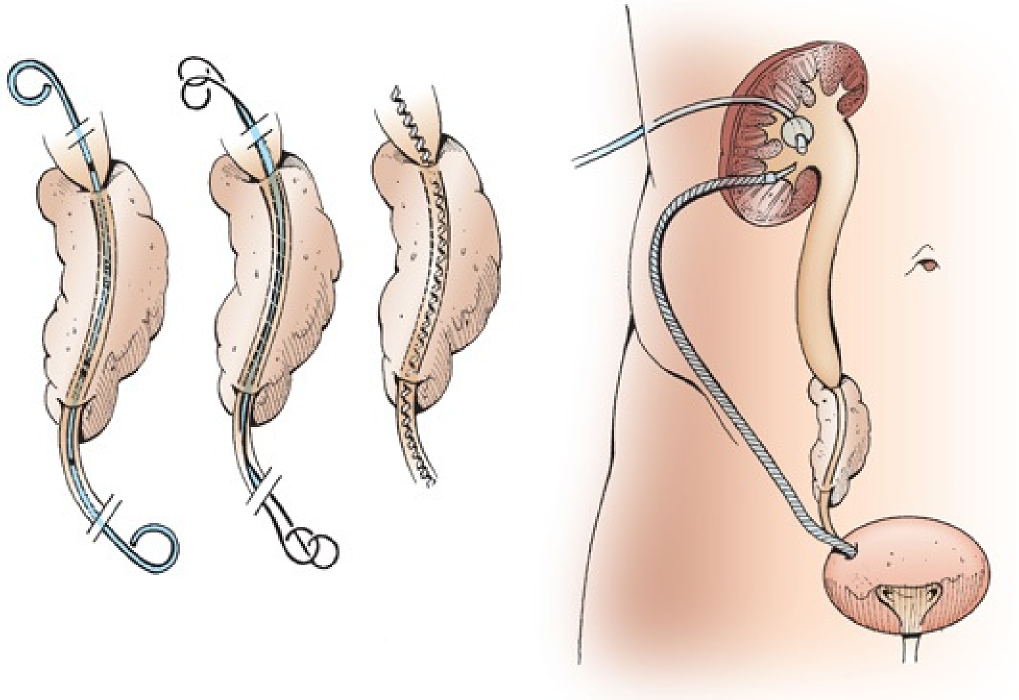

FIGURE 84.2 Endourologic techniques for treatment of malignant ureteric obstruction. **A:** Ureteral stent. **B:** Two parallel ureteral stents. **C:** Metal stent. **D:** Nephrostomy tube. **E:** Extra-anatomic prosthetic bypass.

Under conditions of extrinsic compression, hard polyurethane “tumor stents” are preferred to soft silicone to ensure patency of the stent lumen. Especially for extrinsic compression, newly developed metallic ureteral stents show acceptable results. Additionally, patients in a palliative setting can benefit from a longer dwell time up to 12 months.

In some patients, however, it may be preferable to abstain from any treatment at all. Ishioka et al. (16) developed a risk stratification model for predicting poor survival after palliative urinary diversion (by percutaneous nephrostomy) with three risk groups. They thereby identified three significant risk factors: low preinterventional serum albumin (≤3 g/dL), hydronephrosis grade 1 to 2, and three or more events related to malignant dissemination. The risk groups were defined as favorable (no risk factor), intermediate (one risk factor), and poor (two to three risk factors): Median survival in the favorable risk group was 7 months (1-, 6-, and 12-month survival rates were 97%, 69%, and 39%, respectively) and 3 months in the intermediate risk group (1-, 6-, and 12-month survival rates were, respectively, 76%, 24%, and 5%). In the poor risk group, the median survival was only 2 months (1-, 6-, and 12-month survival rates were 66%, 2%, and 0%, respectively). The differences in the survival profiles were highly significant (16).

Two Double-J Stents

Extensive compression from the tumor may lead to obstruction of conventional double-J stents or may inhibit the urine capillarity along the outside of the double-J stent. When drainage with a single ureteral stent has failed, two 4.7Fr or 7.0Fr double-J stents passed simultaneously over guide wires increase the stiffness and reduce kinking and luminal compression. A decisive factor is the potential space between the stents most likely preserving flow around as well as through them. In all patients, the insertion of two parallel stents was technically possible and in 70% of patients with extrinsic tumor compression, the stents provided sufficient drainage (17,18) (see Fig. 84.2). Alternatively, coiled ureteral stents which do not allow for a complete compression and obstruction because of their outer surfaces can be used.

Metallic Mesh Stents

Metallic mesh stents such as the Wallstent have been used with limited success. Epithelial hyperplasia and tumor ingrowth through the mesh have been reported to result in recurrent ureteral obstruction. These stents are virtually unremovable, and certain problems limit the application of metal mesh stents in the ureter. Therefore, some authors indicate that expandable metallic stents cannot be recommended for malignant ureteral obstruction (19). However, a recent study with a self-expandable, double-layered and coated metallic mesh stent (Uventa) showed a primary success rate of 65% after a follow-up of nearly 1 year. But again, tumor progression was the most common reason for primary stent failure (75.0%) (20).

Extra-anatomic Pyelovesical Prosthetic Bypass

In 1992, Desgrandschamps and colleagues (21) introduced their technique of pyelovesical bypass with a composite prosthesis (internal diameter, 18Fr; external diameter, 28.5Fr), and Jabbour et al. (22) reported long-term results with 35 prosthetic ureters in 27 patients, 22 with malignancies. Minor early and late complications were noted in 5 and 3 patients, respectively. No encrustations of the inner silicone lumen were noted, although asymptomatic bacteriuria sometimes was. The 5 surviving patients (4 with renal transplants, 1 with retroperitoneal fibrosis) were followed from 34 to 84 months (mean, 47 months), and the authors found no encrustation, kinking, or obstruction (22). In cases of persistent vesicovaginal or vesicocutaneous fistula, a pyelocutaneous bypass can also be performed. Data from different work groups suggest that the quality of life may be better for those patients than with conventional nephrostomy tubes.

Transverse Retubularized Colon Segments

In selected patients, transverse reconfigured colon segments may be used successfully to reconstruct extensive ureteral defects (Figs. 84.3 and 84.4). The successful use of a combination of two such segments has been described to divert solitary kidneys in palliative situations (23). In patients with renal insufficiency or a history of irradiation, this technique may be superior to the use of ileum. An advantage of the colon is its immediate proximity to the ureters bilaterally, its position outside the radiation portals for treatment of pelvic malignancy, its optimal cross-sectional diameter for the graft, and low intraperitoneal surgical trauma. Long-time follow-up from our work group shows no impairment of renal function, metabolic disorders, mucus obstruction and stricture, or adhesive ileus for reconfigured colon interponats (24). Nevertheless, unreconfigured colon has not been widely recruited for ureteral replacement because of its wide diameter: Its large volume when replacing long defects could result in metabolic or septic complications. Surgical access is via a flank or pararectal incision, and intraperitoneal surgery is minimal. The colonic segments are taken immediately proximal to the ureteral defect, necessitating little mobilization of the mesenteric pedicle.

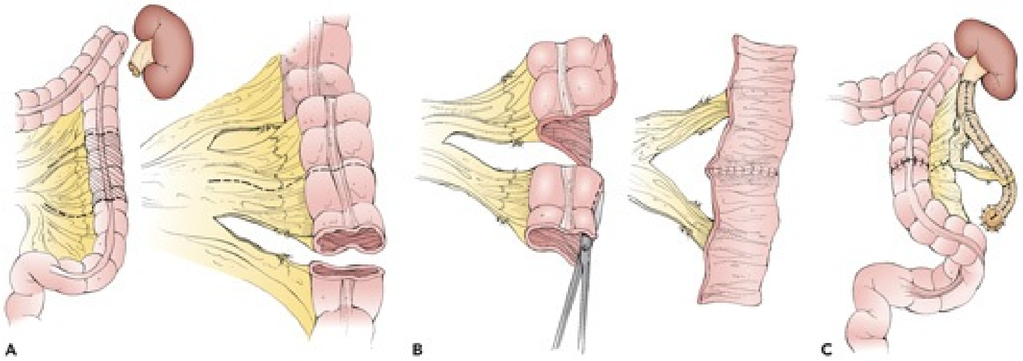

FIGURE 84.3 Combined reconfigured colon segments for incontinent diversion of solitary kidney. **A and B:** A 6-cm segment is excised from the ascending or descending colon. The segment is split in the middle and the rings are opened antimesenterically. When reconfigured, the tube produced will be approximately 18 cm long, suitable for incontinent urinary diversion. **C:** Pyelocolocutaneostomy in a solitary kidney.

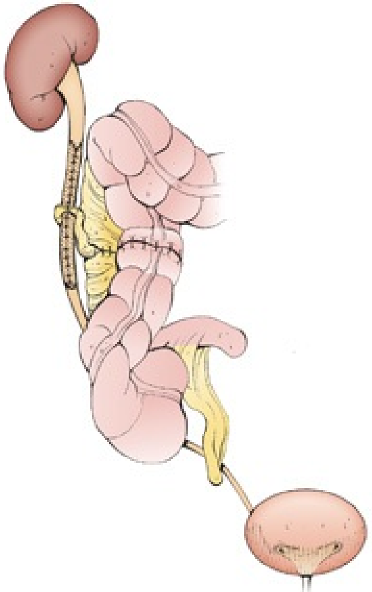

FIGURE 84.4 Interposition of a reconfigured colon segment to repair an extensive ureteral defect.

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SECTION VIII ■ PEDIATRICS

Section Editor: H. GIL RUSHTON

CHAPTER 85 ■ WILMS TUMOR

MARK D. TYSON AND MICHAEL L. RITCHEY

Wilms tumor, or nephroblastoma, is the most common renal tumor of childhood, constituting approximately 6.3% of all cancers and 95% of all kidney cancers in children younger than the age of 15 years in the United States (1,2). According to the Surveillance, Epidemiology, and End-Results (SEER) registry, the average annual age-adjusted incidence rate of Wilms tumor is 8.0 per million, which translates into approximately 500 new cases in the United States per year (1). The incidence is highest among children younger than 2 years of age and declines precipitously with increasing age. The incidence rates are also somewhat higher for females and blacks (3,4).

Although most cases of Wilms tumor are sporadic, up to 10% of Wilms tumors are associated with overgrowth and non-overgrowth syndromes (5). Examples of overgrowth syndromes include Beckwith–Wiedemann syndrome, which is characterized by macroglossia, visceromegaly, and an omphalocele at birth, and is caused by microduplication mutations at 11p15.5. Other overgrowth syndromes include Simpson–Golabi–Behmel syndrome (an X-linked fetal overgrowth syndrome), Perlman syndrome (macrocephaly, macrosomia, visceromegaly, and dysmorphic facial features), and Sotos syndrome (cerebral gigantism). Examples of non-overgrowth syndromes include isolated aniridia, trisomy 18, WAGR syndrome (Wilms tumor, aniridia, genitourinary malformations, and mental retardation), Bloom syndrome (autosomal recessive disorder characterized by short stature, micrognathism, and café au lait spots), and Denys–Drash syndrome (male pseudohermaphrodism and mesangial renal sclerosis). Wilms tumor is also associated with isolated genitourinary anomalies such as hypospadias, cryptorchidism, and renal fusion.

The identification of the relationship between Wilms tumor and WAGR syndrome led to the discovery of genes associated with Wilms tumor. The WT1 gene located on chromosome 11p13 encodes a zinc finger transcriptional factor that serves both tumor-suppressive and developmental regulatory functions (5). Wild-type WT1 is critical in the early embryogenesis of the genitourinary system and is expressed in the kidneys, gonads, spleen, and mesothelium. The incidence of WT1 mutations in patients with nonsyndromal Wilms tumor is 2% (6). Another genetic mutation associated with Wilms tumor has been designated the WT2 gene, located at the chromosome 11p15 locus, which contains a cluster of imprinted genes. Loss of heterozygosity (LOH) at this locus is associated with Beckwith–Wiedemann syndrome.

LOH at chromosome 16q and/or 1p occurs in up to 20% of Wilms tumors (7). These have been shown to be associated with an increased risk for tumor relapse and mortality. In National Wilms Tumor Study (NWTS)-5, patients with stage I or II favorable-histology Wilms tumor (FHWT) and LOH of either 1p or 16q had an increased relative risk of relapse and death compared to patients lacking LOH at either locus. The risks of relapse and death for patients with stage III or IV FHWT were increased only with LOH for both regions.

Nephrogenic rests (NRs) are foci of primitive metanephric tissue that persist into infancy and are found in 1% of postmortem infant kidneys. Because NRs are found in up to 44% of kidneys removed for Wilms tumor and nearly 100% of patients with bilateral Wilms tumors, NR were thought to represent precursor lesions in children genetically predisposed to Wilms tumor. NRs are categorized as either perilobar or intralobar based on their anatomic location within the kidney. Perilobar NRs are observed in kidneys harboring Wilms tumors with WT2 locus deletions, whereas intralobar NRs are more often observed in those with WT1-associated tumors (8). The presence of multiple NRs in the nontumoral portion of a Wilms tumor kidney has been shown to be a risk factor for development of metachronous tumor in the contralateral kidney.

DIAGNOSIS

More than 90% of children with Wilms tumor present with an asymptomatic abdominal mass discovered incidentally by a family member or physician. The mass may be extremely large relative to the size of the child and is not necessarily confined to one side. Approximately 20% of children with Wilms tumor have hematuria at diagnosis and 25% will have hypertension at diagnosis. Gross hematuria warrants further evaluation to rule out tumor extension into the collecting system (9). Other symptoms include fever, anorexia, and weight loss in 10% of patients. Rarely, children may present with acute abdominal pain from tumor rupture into the peritoneal cavity or bleeding within the tumor. Physical examination may reveal a firm, nontender mass that classically does not cross the midline. A persistent varicocele in the supine position or hepatomegaly may be reflective of inferior vena caval obstruction from tumor thrombus. Atrial thrombus may present as hypertension or congestive heart failure.

The preoperative laboratory evaluation of a child with an abdominal mass should include a complete blood count, liver enzymes, and serum electrolytes, including blood urea nitrogen, creatinine, and calcium. Because as many as 8% of newly diagnosed patients with Wilms tumor will have acquired von Willebrand disease, coagulation studies should be considered (10). This includes prothrombin time and partial thromboplastin time, which may be normal in the presence of von Willebrand disease. This defect can be corrected preoperatively with the administration of 1-desamino-8-D-arginine-vasopressin (DDAVP).

The first radiographic study usually obtained in children with an abdominal mass is an abdominal ultrasound, which can differentiate between solid and cystic masses. Real-time ultrasonography of the renal vein and inferior vena cava (IVC) can evaluate for the presence of tumor thrombus in children with renal tumors. All patients should undergo either computerized tomography (CT) of the abdomen and pelvis with oral and intravenous contrast or magnetic resonance (MR) of the abdomen and pelvis with gadolinium. These imaging modalities allow for improved preoperative planning by evaluating for extrarenal spread of disease, the relationship of the tumor to adjacent visceral structures, and the presence of synchronous tumors in the contralateral kidney. The Children’s Oncology Group found that CT has moderate specificity but poor sensitivity in the detection of preoperative tumor rupture. Ascites beyond the cul-de-sac was most strongly associated with tumor rupture (11). Preoperative chest CT with or without contrast is performed to rule out pulmonary metastases (12,13).

INDICATIONS FOR SURGERY

The survival metrics of children with Wilms tumor appear to be improving over time. According to the SEER registry, the relative 5-year survival rate for children younger than the age of 15 years has improved from 73.1% in 1975 to 93.6% in 2002 (2). This improvement in the long-term survival of children with Wilms tumor is a testament to the systematic approach from which multimodal therapy has evolved. Despite the advances in chemotherapy protocols and radiation techniques, a high-quality surgical operation remains paramount in the treatment of Wilms tumor. Primary radical nephrectomy is the procedure of choice for the majority of patients with unilateral Wilms tumor diagnosed in North America. Renal-sparing surgery has been traditionally used in patients with bilateral Wilms tumors. However, the Children’s Oncology Group is now studying the role of renal-sparing surgery for select patients with unilateral tumors. Patients eligible for renal-sparing surgery on this protocol include those with a solitary kidney, a predisposition syndrome where tumors are found at a smaller size, and patients with an increased risk for developing renal failure (14,15). Several small single institution reports have documented the feasibility of partial nephrectomy in select cases of “low-risk” unilateral tumors, where nephron preservation is not imperative and where the risk of metachronous tumor formation is low (16). With respect to laparoscopy, there are reports in children with unilateral nonmetastatic Wilms tumor who received preoperative chemotherapy (17). However, the role of laparoscopy prior to chemotherapy may be limited because of large tumor size and risk of intraoperative spillage.

Tumor histology and stage are the most important determinants of prognosis in patients with Wilms tumor. Tumor grade, particularly the presence of anaplasia, is the most important prognostic factor and portends a poorer prognosis compared to favorable histology. The staging system used by the Children’s Oncology Group is presented in Table 85.1 and is based on various intraoperative and pathologic findings.

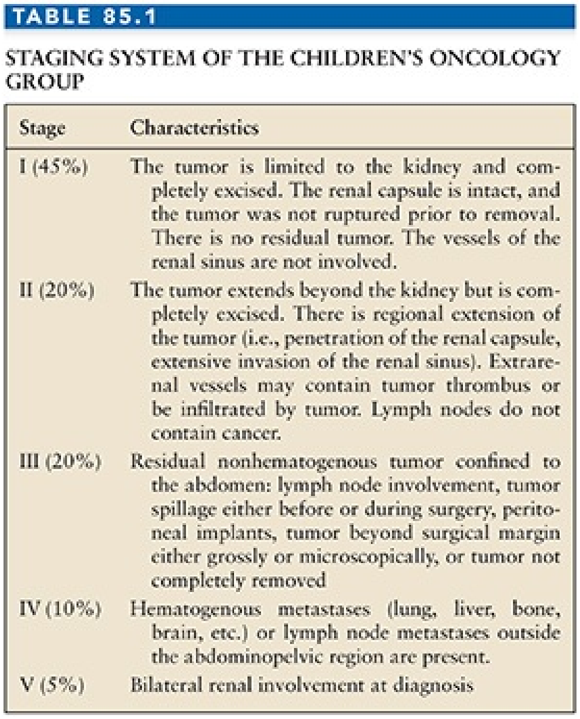

TABLE 85.1

STAGING SYSTEM OF THE CHILDREN'S ONCOLOGY GROUP

Stage	Characteristics
I (45%)	The tumor is limited to the kidney and completely excised. The renal capsule is intact, and the tumor was not ruptured prior to removal. There is no residual tumor. The vessels of the renal sinus are not involved.
II (20%)	The tumor extends beyond the kidney but is completely excised. There is regional extension of the tumor (i.e., penetration of the renal capsule, extensive invasion of the renal sinus). Extrarenal vessels may contain tumor thrombus or be infiltrated by tumor. Lymph nodes do not contain cancer.
III (20%)	Residual nonhematogenous tumor confined to the abdomen: lymph node involvement, tumor spillage either before or during surgery, peritoneal implants, tumor beyond surgical margin either grossly or microscopically, or tumor not completely removed
IV (10%)	Hematogenous metastases (lung, liver, bone, brain, etc.) or lymph node metastases outside the abdominopelvic region are present.
V (5%)	Bilateral renal involvement at diagnosis

PREOPERATIVE CONSIDERATIONS

The International Society of Pediatric Oncology (SIOP) advocates preoperative chemotherapy for all patients with Wilms tumor regardless of the extent of disease (18). Preoperative treatment can produce dramatic reduction in the size of the primary tumor, facilitating surgical excision. The SIOP trials have demonstrated that the incidence of tumor rupture is lower after preoperative therapy. There is no survival advantage over a primary surgical approach. The Children's Oncology Group (COG) recommends preoperative chemotherapy in children with bilateral tumors, tumors inoperable at surgical exploration, or IVC extension above the hepatic veins. All other patients are recommended to undergo primary excision of the tumor. This allows precise staging of patients with modulation of treatment for each individual, thereby decreasing the intensity of treatment when possible while maintaining excellent overall survival.

SURGICAL TECHNIQUE

The recommended surgical approach for Wilms tumor is through a transperitoneal transabdominal incision. An extraperitoneal flank incision should be avoided because it does not allow for proper staging. A generous transverse abdominal incision allows for inspection and exploration of the abdominal cavity. The patient is placed in a supine position with mild flexion of the lumbar spine to facilitate the exposure of retroperitoneal structures. The incision is made approximately two fingerbreadths above the umbilicus beginning in the midaxillary line on the side of the neoplasm. The extent to which the incision is extended across the midline will vary with the size of the tumor and amount of exposure needed. The incision may be extended into a thoracoabdominal approach by continuing through the bed of the 9th or 10th rib, if necessary. The muscle layers are divided sequentially to facilitate exposure. The peritoneal space should be opened carefully. The tumor may compress the colon and/or small bowel against the anterior abdominal wall, inadvertently resulting in enterotomy. A thorough exploration of the abdomen is performed. The peritoneal cavity is assessed for evidence of preoperative tumor rupture and peritoneal implants. The liver is carefully examined, as liver metastases may not be identified on preoperative imaging studies. An assessment of tumor extent is performed next, including palpation of the IVC and assessment of regional lymphadenopathy, perinephric extension, and tumor mobility. Formal exploration of the contralateral kidney is not needed if preoperative imaging does not demonstrate bilateral lesions (19).

Following exploration of the abdominal cavity, the colon is reflected medially by incising the white line of Toldt. The colonic mesentery is mobilized, with care taken to preserve the colonic vessels that may be draped over the tumor. The colon can then be retracted medially to expose the renal vessels (Fig. 85.1). For right-sided tumors, the posterior peritoneum can be incised up to the base of the mesentery. This will allow reflection of the entire colon and small bowel, which provides excellent exposure of the retroperitoneal vessels. Early ligation of the renal vessels before manipulation is ideal. The renal vessels are identified and encircled individually with vessel loops. The artery can be identified with careful retraction of the vein. The renal vein and IVC should be carefully palpated for the presence of Wilms tumor thrombus, which occurs in 4% and 0.7% of patients, respectively. Prior to ligation of the vessels, the contralateral renal vessels and superior mesenteric artery are identified to avoid injury to these structures. Large tumors can significantly distort vascular anatomy. The renal vessels are then doubly ligated and divided. The renal artery should be ligated prior to the renal vein in order to avoid distention of the vein, which can dislodge the ligature. Early ligation of the renal vessels also decreases the theoretical risk of tumor dissemination. Preliminary ligation of the renal vessels should not be pursued if technically difficult or dangerous.

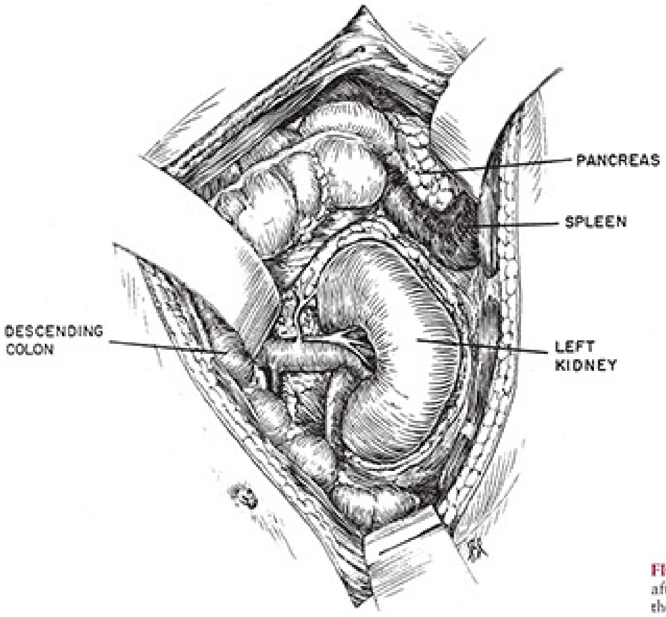

FIGURE 85.1 Descending colon retracted medially after incising of the line of Toldt and mobilizing of the mesocolon off the anterior surface of the tumor.

An alternative for management of the renal vein is to place a Satinsky clamp on the vena IVC just proximal to the insertion of the renal vein. This maneuver can be valuable when the vein is short or if there is tumor extension beyond the renal vein. The tumor thrombus is gently milked back prior to placement of the Satinsky clamp. The renal vein is then divided and the venous stump is oversewn with continuous 5-0 Prolene in two layers (Fig. 85.2).

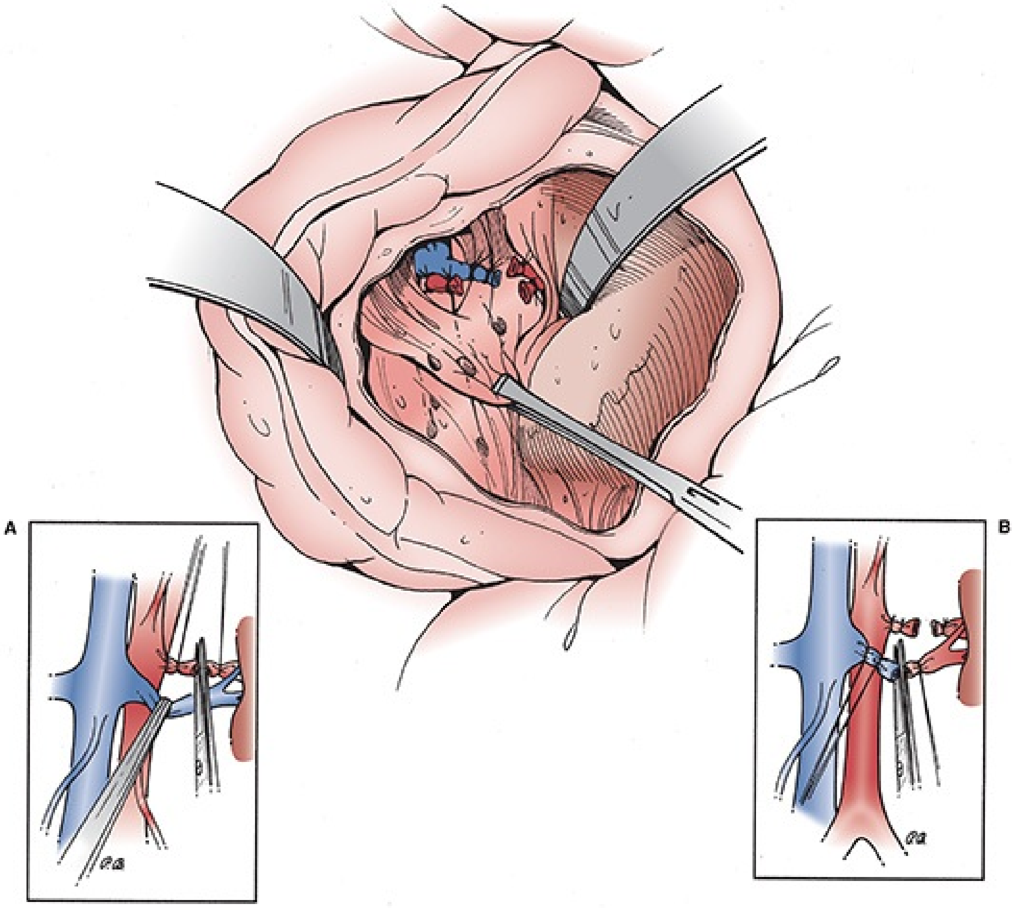

FIGURE 85.2 Mobilization of left-sided Wilms tumor by blunt dissection after ligation and division of the (A) renal artery and (B) vein.

If tumor thrombus is present in the IVC, additional surgical exposure is warranted. Both proximal and distal vascular control is necessary. For minimal thrombus extension below the level of the hepatic veins, the inferior edge of the liver can be retracted to expose the infrahepatic vena cava.

For a tumor that extends more cephalad, mobilization of the liver is required. Division of the triangular and coronary ligaments of the liver allows rotation and exposure of the retrohepatic vena cava. Additional exposure can be gained by dividing the lesser hepatic veins. The contralateral renal vein and infrarenal IVC are controlled with vessel loops. The IVC is then vertically incised just medial to the entrance of the renal vein. If the thrombus is free-floating, it is manually extracted at this point. In many cases, the thrombus is adherent to the wall of the IVC. A Fogarty or Foley balloon catheter can be passed beyond the level of the hepatic veins and then inflated. The catheter is then pulled inferiorly, thus displacing the adherent thrombus into the cavotomy. The IVC is allowed to fill by releasing the vessel loops on the distal cava and contralateral renal vein. This will displace the air from within the IVC. The cavotomy is then clamped with a Satinsky clamp and oversewn with a continuous 5-0 Prolene suture (Fig. 85.3). In rare instances, tumor thrombus invades the wall of the IVC, precluding thrombectomy, and this may necessitate partial resection of the IVC.

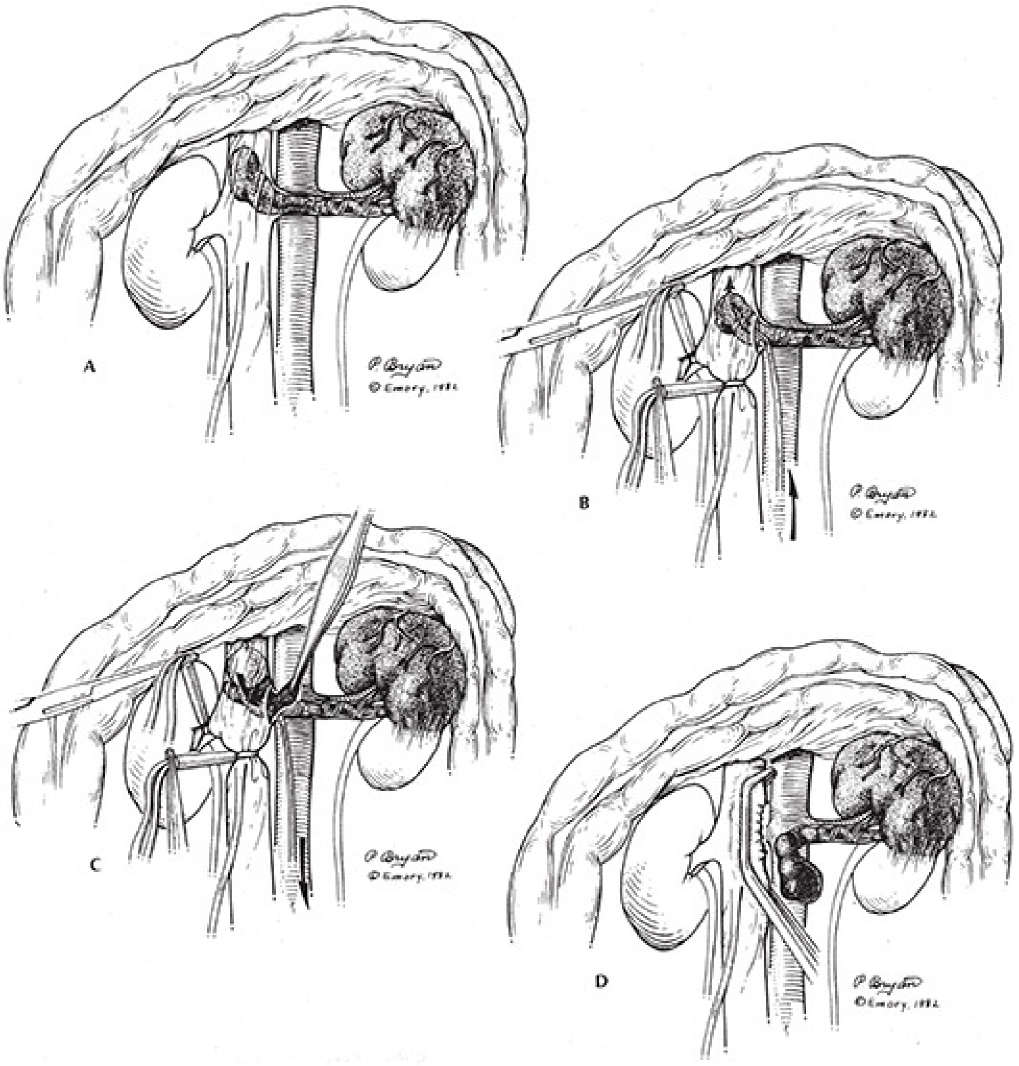

FIGURE 85.3 Surgical technique to manage tumor extension through the renal vein. **A:** Tumor extension into the vena cava (limited to the infrahepatic level). **B:** After exposure of the vessels, the infrarenal vena cava and contralateral renal vein are controlled with vessel loops, and the vena cava is incised vertically at the intersection with the renal vein. A Fogarty catheter (*arrow*) is passed superior to the tumor thrombus **C:** The balloon of the Fogarty catheter is inflated and traction placed downward (*arrow*) to pull the thrombus from the cava. **D:** The vena cava is flushed of air and a Satinsky clamp is placed to allow closure of the cavotomy.

Patients with IVC extension above the level of the hepatic veins or atrial thrombus remain a difficult surgical challenge. Pretreatment with chemotherapy is recommended to decrease surgical morbidity. If this fails to shrink the thrombus or if a primary surgical approach is chosen, the procedure may require cardiopulmonary bypass and benefit from a combined abdominothoracic approach with a pediatric cardiothoracic surgeon. Suprahepatic or atrial involvement is best approached through a median sternotomy. This can be performed in conjunction with a subcostal incision or a midline abdominal incision required for nephrectomy.

After the vessels are controlled, a dissection plane is established outside of the fascia of Gerota by sharp and blunt dissection. The perforating vessels can be quite large and should be ligated individually. Gentle manipulation of the tumor should be emphasized. Wilms tumors are very soft and may easily rupture, leading to tumor spill and an increased risk of local recurrence (20). It is not necessary to remove the adrenal gland with the specimen if there is no evidence of direct involvement with tumor. Involvement of the adrenal gland has been noted in 4% of patients but is noted more often with higher stage disease (21).

The ureter is palpated to rule out intraureteral extension before it is divided as distally as possible (9). Formal lymph node dissection is not required, but all suspicious lymph nodes should be biopsied. Lymphatic tissue in the renal hilum and adjacent precaval and preaortic areas is generally removed with the specimen. Failure to sample lymph nodes will mandate increased therapy due to an increased risk of local recurrence secondary to incomplete staging (22). Lymph node involvement and microscopic residual disease were the stage III criteria that were most predictive of event-free and overall survival in the NWTS-5 (23). After extraction of the intact tumor, the wound is copiously irrigated and hemostasis is assessed. Drains are not routinely placed unless a portion of the pancreas or liver has been resected. The displaced colon is replaced in the tumor bed.

Bilateral Tumors

Synchronous bilateral Wilms tumor occurs in 4% to 6% of patients with Wilms tumor (24). Children with bilateral Wilms tumors should not undergo initial radical nephrectomy; rather, they should receive preoperative chemotherapy with the goal of tumor shrinkage and renal preservation. Children treated with preoperative chemotherapy will have more renal units preserved. This is important because the risk of renal failure in patients with bilateral disease approaches 15% at 15 years posttreatment (14,25).

The current COG-AREN0534 protocol for patients with bilateral Wilms tumor recommends a 6-week regimen of vincristine, dactinomycin, and doxorubicin prior to surgery (24). Tumor response is evaluated with CT or MR after 6 weeks. Patients with tumors amenable to renal-sparing procedures can proceed with surgery. If there has not been a good response, biopsy of the tumor(s) is recommended to determine the histology. Additional chemotherapy is then given, but all patients should proceed to surgical resection within 12 weeks of starting therapy.

At the time of definitive surgery, partial nephrectomy or wedge excision of the tumor is preferred but only if complete removal of the tumor can be achieved. The kidney with the lower tumor burden is addressed first. If complete excision of tumor from this kidney can be performed leaving a viable and functioning kidney, then surgery of the contralateral kidney with more extensive tumor involvement is done. Enucleation of the tumor may be considered in lieu of a formal partial nephrectomy. This will usually be considered for large centrally located tumors where removal of a margin of renal tissue would compromise the vascular supply to the kidney. Even when very large bilateral masses remain after initial chemotherapy, a high percentage of children can be successfully managed with renal-sparing surgery (26). It is easy to underestimate the amount of renal parenchyma that can be salvaged due to compression by the tumor; therefore, renal-sparing surgery should be entertained in all patients. One concern regarding enucleation of large centrally located tumors is the potential for positive surgical margins. Kieran et al. (27) reported a 23% incidence of positive surgical margins in a cohort of patients with bilateral Wilms tumor undergoing renal-sparing surgery. They did not demonstrate an increased risk of local recurrence, but this was a small number of patients with all receiving postoperative radiation.

Adjuvant Therapy

All clinical trials for children with Wilms tumor strive to tailor treatment to individual risks for tumor recurrence and reduce the overall morbidity of treatment. The latter will allow clinicians to reduce treatment-related side effects. Current treatment recommendations of the COG are listed in Table 85.2 (28). All renal tumors are eligible for enrollment in COG protocols, including renal cell carcinoma and congenital mesoblastic nephroma.

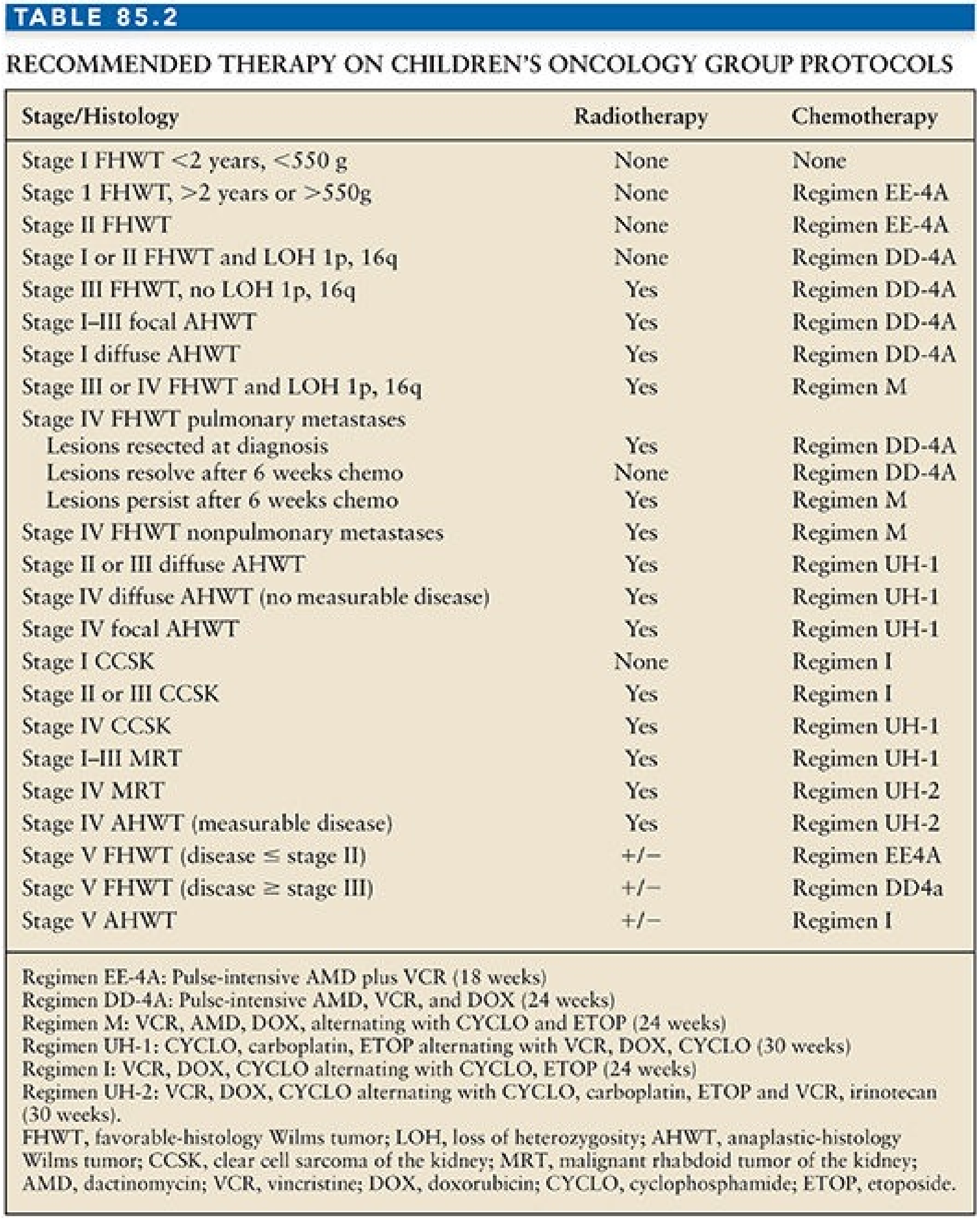

TABLE 85.2

RECOMMENDED THERAPY ON CHILDREN'S ONCOLOGY GROUP PROTOCOLS

Stage/Histology	Radiotherapy	Chemotherapy
Stage I FHWT <2 years, <550 g	None	None
Stage 1 FHWT, >2 years or >550g	None	Regimen EE-4A
Stage II FHWT	None	Regimen EE-4A
Stage I or II FHWT and LOH 1p, 16q	None	Regimen DD-4A
Stage III FHWT, no LOH 1p, 16q	Yes	Regimen DD-4A
Stage I–III focal AHWT	Yes	Regimen DD-4A
Stage I diffuse AHWT	Yes	Regimen DD-4A
Stage III or IV FHWT and LOH 1p, 16q	Yes	Regimen M
Stage IV FHWT pulmonary metastases		
Lesions resected at diagnosis	Yes	Regimen DD-4A
Lesions resolve after 6 weeks chemo	None	Regimen DD-4A
Lesions persist after 6 weeks chemo	Yes	Regimen M
Stage IV FHWT nonpulmonary metastases	Yes	Regimen M
Stage II or III diffuse AHWT	Yes	Regimen UH-1
Stage IV diffuse AHWT (no measurable disease)	Yes	Regimen UH-1
Stage IV focal AHWT	Yes	Regimen UH-1
Stage I CCSK	None	Regimen I
Stage II or III CCSK	Yes	Regimen I
Stage IV CCSK	Yes	Regimen UH-1
Stage I–III MRT	Yes	Regimen UH-1
Stage IV MRT	Yes	Regimen UH-2
Stage IV AHWT (measurable disease)	Yes	Regimen UH-2
Stage V FHWT (disease ≤ stage II)	+/−	Regimen EE4A
Stage V FHWT (disease ≥ stage III)	+/−	Regimen DD4a
Stage V AHWT	+/−	Regimen I

Regimen EE-4A: Pulse-intensive AMD plus VCR (18 weeks)
Regimen DD-4A: Pulse-intensive AMD, VCR, and DOX (24 weeks)
Regimen M: VCR, AMD, DOX, alternating with CYCLO and ETOP (24 weeks)
Regimen UH-1: CYCLO, carboplatin, ETOP alternating with VCR, DOX, CYCLO (30 weeks)
Regimen I: VCR, DOX, CYCLO alternating with CYCLO, ETOP (24 weeks)
Regimen UH-2: VCR, DOX, CYCLO alternating with CYCLO, carboplatin, ETOP and VCR, irinotecan (30 weeks).
FHWT, favorable-histology Wilms tumor; LOH, loss of heterozygosity; AHWT, anaplastic-histology Wilms tumor; CCSK, clear cell sarcoma of the kidney; MRT, malignant rhabdoid tumor of the kidney; AMD, dactinomycin; VCR, vincristine; DOX, doxorubicin; CYCLO, cyclophosphamide; ETOP, etoposide.

The first generation of COG studies (2006 to 2013) grouped patients by risk for recurrence (very low, low, standard, and high). The COG again examined the role of surgery-only treatment for patients with stage I FHWT weighing <550 g and age <2 years. Children with stage I or II FHWT and LOH of 1p and 16q were treated with vincristine (VCR), dactinomycin (AMD), and doxorubicin (DOX) without radiotherapy. Patients with stage III FHWT disease without LOH of 1p and 16q were treated with VCR, AMD, and DOX and irradiation of the flank or abdomen. The COG evaluated a response-based approach for management of children with pulmonary metastases. Those with resolution of the pulmonary lesions on chest CT after 6 weeks of chemotherapy were treated with VCR, AMD, and DOX. Patients who did not have resolution of the pulmonary lesions by week 6 received more intensive chemotherapy and pulmonary irradiation. Children with stage I to III focal anaplastic-histology Wilms tumor (AHWT) and stage I diffuse AHWT were treated with AMD, VCR, DOX, and abdominal irradiation. Patients with stage II, III or IV (no measurable disease) diffuse AHWT, stage IV focal AHWT, stage IV clear cell sarcoma, and stage I to III malignant rhabdoid tumor were treated with a new chemotherapy regimen to try to improve overall survival. All of the COG studies are closed to patient accrual with results not yet reported.

OUTCOMES

Complications

The most common intraoperative complication of nephrectomy for Wilms tumor is bleeding. Major vascular injuries and injury to other organs are less frequent. Following surgery, the most common complication is small bowel obstruction, which occurs in about 5% of patients (29). The surgical complication rate of nephrectomy for Wilms tumor has declined over the past three decades.

Preoperative chemotherapy may influence surgical complication rates by producing tumor shrinkage (30). A recent report from the United Kingdom Children’s Cancer Study Group compared the complication rate for patients undergoing immediate nephrectomy compared to delayed nephrectomy performed after 6 weeks of chemotherapy (31). They found significantly fewer complications in those undergoing delayed nephrectomy (1% versus 5.8%). They also noted a much higher rate of tumor rupture/spill in those undergoing immediate nephrectomy (14.6% versus 0%). This is similar to the rate of intraoperative tumor spill following immediate nephrectomy recently reported by the COG (32).

A mortality rate of 0.5% related to surgical complications was reported from NWTS-3. However, a higher intraoperative mortality rate of 1.5% has been reported from other centers. The latter may reflect that intraoperative deaths may not be reported to the cooperative groups since study enrollment occurs after surgery. Factors that have been associated with an increased risk for surgical complications are higher tumor stage, tumor size >10 cm, incorrect preoperative diagnosis, thoracoabdominal incision, intracaval tumor extension, and resection of other visceral organs.

Tumor Recurrence

Common sites of recurrence are the lungs, liver, and renal fossa. Approximately 15% of children with favorable histology Wilms tumor and up to 50% of children with anaplastic elements will develop recurrent disease. Tumor histology and clinical stage are the most important predictors of outcome. There is an increased risk for local recurrence in the setting of unfavorable histology and intraoperative tumor rupture (20). Omission of lymph node biopsy also correlates with recurrence and is attributed to understaging. Preventing local recurrence is important as the survival after abdominal recurrence is poor (5-year survival rate of 60%) (33,34). Current trials continue to refine chemotherapeutic regimens to improve survival, in particular for higher risk populations with unfavorable histology. The use of biologic factors to further stratify patients for therapy may further advance survival and minimize late effects of treatment.

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CHAPTER 86 RENAL FUSION AND ECTOPIA

ROSS M. DECTER AND AMY S. BURNS

Abnormalities of renal position and fusion predispose to infection, hydronephrosis, stone disease, and, in some instances, neoplasia. Although clinical problems associated with these anomalies present infrequently in urologic practice, an understanding of the deviations from standard urologic techniques required to address them is important.

The ureteral bud branches from the wolffian duct and extends toward the metanephric blastema during the fourth and fifth weeks of gestation. The ureteral bud induces the metanephric blastema to form the functioning kidney. The exact mechanism of renal ascent is not known, but during normal development, the kidneys ascend and rotate. The renal pelvis rotates from its initial anterior position 90 degrees toward the midline until it reaches its final medial position. Migration and rotation occur simultaneously between the fourth and eighth or ninth weeks of gestation. The blood supply to the kidney is derived from successively higher levels of the aorta and its branches during ascent.

The most common anomaly of renal position is malrotation: incomplete rotation of the kidney to its final position. The renal pelvis in a malrotated kidney in general lies anterior to the parenchyma, as opposed to its normal medial location. Simple malrotation of a normally positioned kidney is often an incidental finding. The pyelocaliceal systems of malrotated kidneys are morphologically abnormal, but functionally, they usually drain without impairment. Malrotation occurs occasionally in orthotopically positioned kidneys, and it is commonly observed in ectopic kidneys.

Close approximation of the two proliferating renal blastemas prior to significant ascent is a normal embryologic finding (1). If there is any disturbance of separation of the closely approximated renal blastemas, fusion anomalies of the kidneys may develop.

The most common fusion anomaly is the horseshoe kidney. The horseshoe kidney in general ascends until the upper border of the isthmus is at the level of the inferior mesenteric artery. Horseshoe kidney occurs in 1 in 400 to 1 in 1,800 births (2). There is a male predominance for the condition (3). The fusion in horseshoe kidney almost always occurs at the lower poles; cases of upper pole fusion are recorded rarely (3). The isthmus of the horseshoe kidney lies just below the inferior mesenteric artery at the L4 vertebral level. The blood supply to these kidneys is variable (Fig. 86.1).

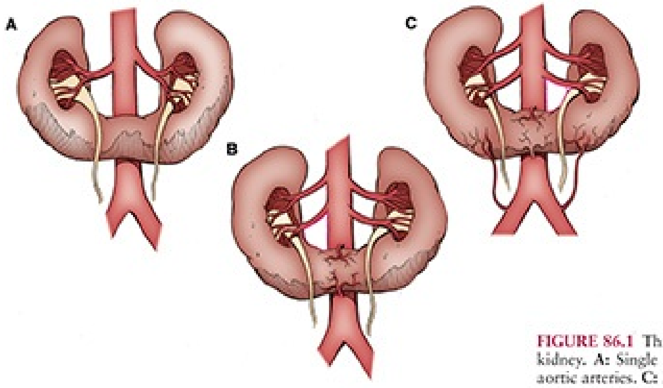

FIGURE 86.1 Three common variants of blood supply in horseshoe kidney. **A:** Single renal arteries arising from the aorta. **B:** Multiple aortic arteries. **C:** Multiple aortic and iliac arteries.

Crossed fused ectopia is the second most common fusion anomaly. This abnormality occurs when the developing kidney crosses from one side to the other during its ascent or when the ureteral bud from one side crosses to the contralateral side and induces abnormal development of that metanephric blastema. Crossed ectopia with fusion may occur in a variety of forms (Fig. 86.2). Although crossed ectopia occurs most frequently with fusion, the anomaly may occur without fusion (Fig. 86.3). The diagnosis should be considered in patients with a prenatal diagnosis of solitary kidney or an empty unilateral renal fossa (Fig. 86.4).

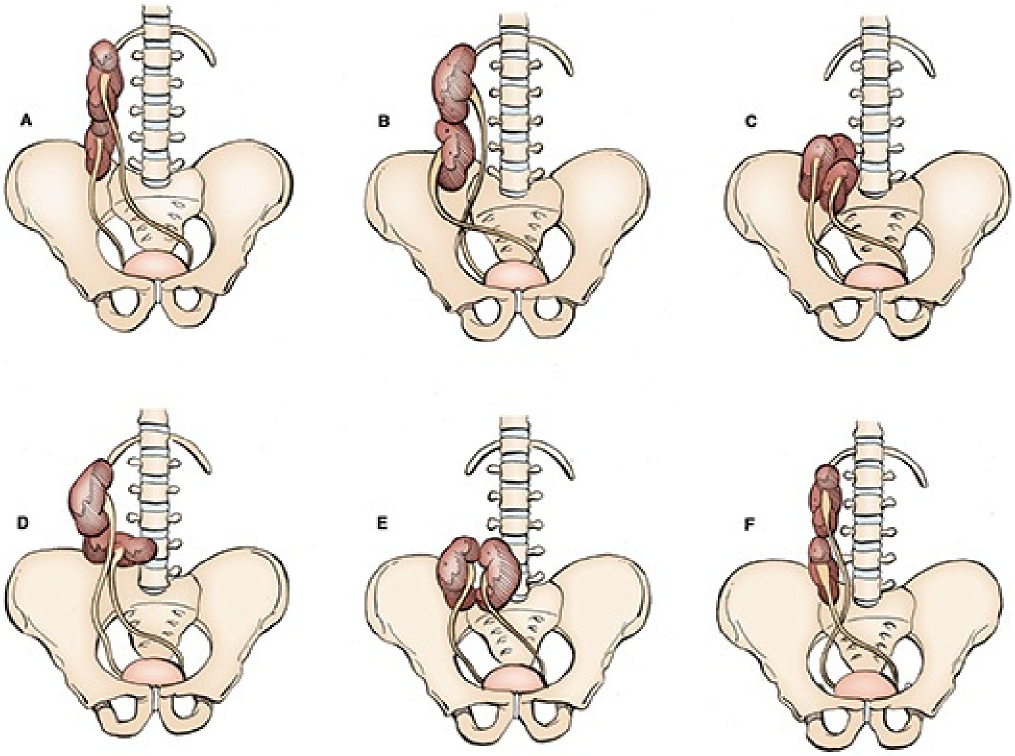

FIGURE 86.2 Six types of crossed renal ectopia with fusion. **A:** Ectopic kidney superior. **B:** Sigmoid or S-shaped kidney. **C:** Lump kidney. **D:** L-shaped kidney. **E:** Disk kidney. **F:** Ectopic kidney inferior. (Modified with permission from McDonald JH, McClellan DS. Crossed renal ectopia. *Am J Surg* 1957;93:995. Copyright © 1957 Published by Elsevier Inc.)

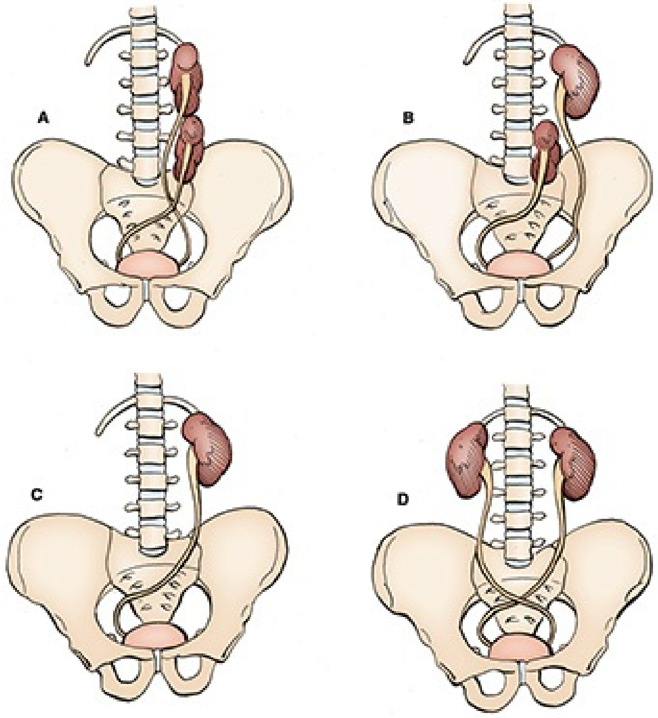

FIGURE 86.3 Types of crossed renal ectopia. A: Fused. B: Nonfused. C: Solitary. D: Bilateral. (Modified with permission from McDonald JH, McClellan DS. Crossed renal ectopia. *Am J Surg* 1957;93:995. Copyright © 1957 Published by Elsevier Inc.)

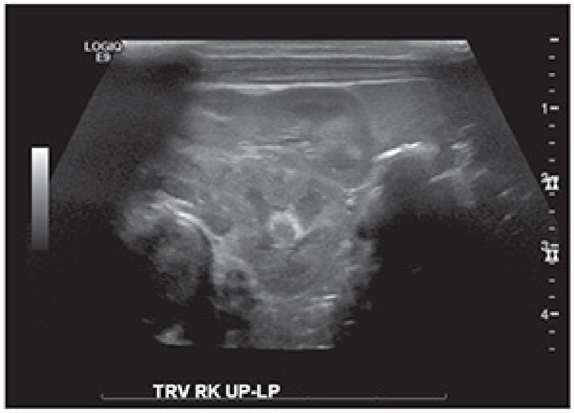

FIGURE 86.4. Crossed fused ectopia. Prenatal sonogram detected presumed solitary kidney. Postnatal sonogram revealed two distinct, but fused, renal units are seen in the right renal fossa, whereas no other renal unit was identified within the abdomen on surveillance sonography.

An ectopic kidney lies outside of the normal position in the renal fossa. The kidney, in simple ectopia, in general, lies in the ipsilateral retroperitoneal space at a position that is lower than normal (Fig. 86.5). In crossed ectopia, the kidney crosses the midline and is frequently fused to its contralateral mate. The autopsy incidence of renal ectopia is about 1 in 1,000 cases, and the condition often is totally asymptomatic (4). Reviews of renal ectopia show that the left kidney is affected slightly more frequently than the right. Ectopic kidneys occur bilaterally around 10% of the time, and the most common position of the ectopic kidney is in the pelvis. Pelvic ectopia was reported in about 55% of patients in one series of ectopic kidneys, crossed fused ectopia occurred in 27%, lumbar ectopia occurred in 12%, non–crossed fused ectopia occurred in 5% of patients, and a thoracic kidney was recorded only 1% of the time (4). Rarely, a solitary pelvic kidney occurs. Obstruction or infection in the previously undiagnosed pelvic kidney can be mistaken for other intra-abdominal pathology, such as appendicitis. Furthermore, this kidney suffers the risk of injury during pelvic surgical procedures and on occasion has been reported as an unusual cause of giant hydronephrosis.

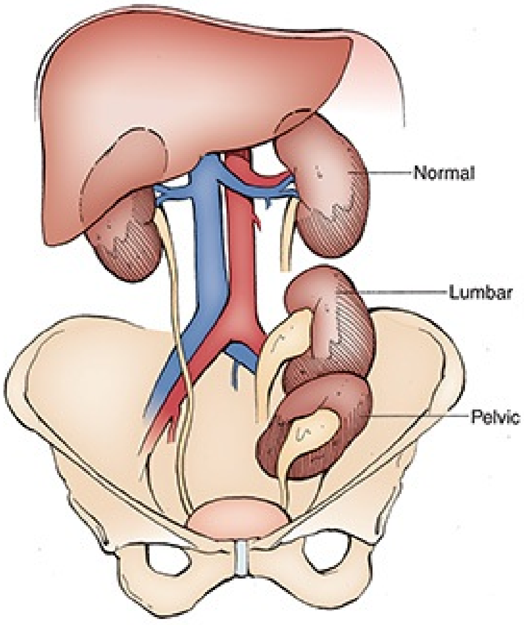

FIGURE 86.5 Location of lumbar and pelvic ectopically positioned kidneys in relation to the normally positioned kidney.

Ectopic kidneys are smaller than their orthotopically positioned mates (5). The blood supply to the pelvic kidney, the most common of the ectopic kidneys, is variable. The arterial supply may arise from the distal aorta or bifurcation, the ipsilateral common iliac, or the hypogastric vessels. In general, the lower the kidney is in its pelvic location, the greater the likelihood that multiple arterial vessels will supply it (6).

DIAGNOSIS

Horseshoe Kidney

Historically, 25% to 33% of patients with horseshoe kidneys who survived beyond the newborn period were asymptomatic (3). The advent of prenatal ultrasound screening makes it likely that an even larger proportion of these kidneys are asymptomatic. Patients with symptoms typically present with urinary tract infections (about 50% of the time), an abdominal mass, hematuria, or abdominal pain (approximately 10% each). Stone prevalence in horseshoe kidneys ranges from 20% to 50% (7).

The initial diagnostic evaluation in children is usually a renal ultrasound (RUS); however, sonographic detection of a horseshoe kidney can be difficult unless an isthmus is seen. Among 34 patients with known horseshoe kidney in one study, only 27 had a detectable isthmus on sonography. Other sonographic features suggesting the presence of a horseshoe kidney were low-lying renal units (78%), malrotation with anteriorly pointing pelvis (36%), bent or curved configuration of the kidney in the long axis (58%), tapering and elongation of the lower pole (60%), and a poorly defined inferior border of the kidney (84%) (8). In instances of hydronephrosis and obstruction, nuclear medicine imaging may detect presence of an isthmus not visualized on sonography (9). Because of the variability in detection of horseshoe kidney via imaging studies typically employed in children, a high index of suspicion should be maintained when performing renal surgery in children when aberrant or unexpected anatomy is encountered intraoperatively.

Symptomatic adults typically undergo computerized axial tomography (CT) where the isthmus is typically readily visible. Historically, many adults underwent intravenous pyelography (IVP) as their initial study, and the IVP features of the horseshoe kidney are typical. The renal axis is abnormal, being either vertically orientated or tilted laterally. The renal pelves tend to be located anteriorly and the ureters course ventral to the isthmus. The lower calices are oriented caudally or even medially as opposed to laterally.

Kidneys with fusion anomalies are subject to a high incidence of vesicoureteral reflux, variably reported between 20% and 50%. Voiding cystourethrography (VCUG) is therefore suggested during the evaluation of children with a horseshoe kidney.

The diagnosis of a ureteropelvic junction (UPJ) obstruction in a horseshoe kidney is straightforward when the patient's symptoms lead to an RUS, IVP, or CT that reveals significant pyelocaliectasis. In other instances, with less severe dilation, and especially when there is coexistent stone disease, we find the diuretic renal scan a valuable adjunct in assessing the drainage of these systems and assessing whether the hydronephrosis is functionally significant.

Ectopic Kidney

Patients with a symptomatic ectopic kidney frequently present with a urinary tract infection, or the ectopic kidney is discovered in the evaluation of abdominal pain. The workup of a palpable abdominal mass and the discovery of the abnormal renal position during the evaluation of other anomalies each account for the diagnosis in about 20% of cases. Hematuria, incontinence, renal insufficiency, and nephrolithiasis are less common presenting complaints. It is important to emphasize that the majority of patients with ectopic kidneys are asymptomatic.

The evaluation in children is usually by RUS, while older patients will in general have an IVP or CT scan. The ectopic kidney can be difficult to detect on the IVP because the pyelocaliceal system often overlies the bony pelvis. Ectopic kidneys have a high incidence of associated vesicoureteral reflux, so a VCUG is a suggested part of the evaluation of these patients. Functional evaluation of the ectopically positioned kidney can be performed with a renal scan. Because the ectopic kidney is in a different plane from the orthotopic kidney, it is necessary to calculate a geometric mean from both posterior and anterior views in order to obtain an accurate differential renal function. Typically, these studies demonstrate decreased function in the ectopic kidney when compared to the normally positioned contralateral kidney. The true use, however, of a functional study is questionable, particularly if there is no evidence of reflux or hydronephrosis suggesting possible obstruction as management of these patients is not impacted. Thus, a functional study is not compulsory.

INDICATIONS FOR SURGERY

The indications for surgical intervention in the ectopic or horseshoe kidney are similar to those in a normally positioned kidney. Pyeloplasty is required in patients with symptomatic UPJ obstruction or when the evaluation suggests that the abnormality at the UPJ may affect ultimate renal function. Symptomatic stone disease needs to be addressed using open, endoscopic, laparoscopic, or extracorporeal techniques. If the evaluation of infections in a horseshoe kidney reveals vesicoureteral reflux, operative management, either subureteral injection of Deflux or ureteral reimplantation, may be warranted if clinically indicated.

ALTERNATIVE THERAPY

The alternative to surgical intervention for reflux is nonoperative management, usually consisting of observation either with or without antibiotic prophylaxis.

Surgery is the only viable option for patients with significant UPJ obstruction, sizeable stones, and tumors. Endopyelotomy has been utilized to treat UPJ obstruction in horseshoe kidneys. The initial results of endopyelotomy performed in adults by experienced surgeons are encouraging; however, formal pyeloplasty is the initial procedure for UPJ obstructions in children.

SURGICAL TECHNIQUE

Pyeloplasty

Pyeloplasty is the most common open procedure performed on the horseshoe kidney. Division of the isthmus with nephropexy had been considered to be an important part of the procedure, but previous experience suggests that isthmus division or symphysiotomy is rarely necessary in the correction of UPJ obstruction. Pyeloplasty may be performed either open or laparoscopically. Laparoscopic procedures can be accomplished with or without robotic assistance. Laparoscopic and robotic-assisted laparoscopic pyeloplasty is more widely practiced in orthotopic renal units and is also a viable option in addition to open pyeloplasty in abnormally positioned kidneys (10–12).

The surgical exposure of the horseshoe kidney can be achieved through a midline transperitoneal, anteriorly positioned flank extraperitoneal, or transverse transperitoneal approach. We prefer the transverse transperitoneal exposure as it seems to provide the widest exposure with a cosmetically acceptable scar. We perform a retrograde ureteropyelogram at the time of pyeloplasty so we can position the incision accurately. The incision generally extends from the anterior axillary line on the affected side to the midline several centimeters below the umbilicus. It can be extended laterally in either direction if necessary. For a right-sided UPJ obstruction, the posterior peritoneum may be incised medial to the inferior mesenteric vein, then inferior and laterally along the small bowel mesentery around the cecum, and up along the line of Toldt. The small bowel and cecum can then be reflected upward out of the operative field and packed in the upper abdomen. For a left-sided UPJ obstruction, the sigmoid colon may be mobilized if necessary to afford better exposure. Exposure is maintained with a ring retractor.

Repair of UPJ obstruction in the horseshoe kidney can be performed by a Foley Y-V plasty or a dismembered pyeloplasty. Although the Foley Y-V repair is nicely suited to the typical high-insertion obstruction seen in horseshoe kidneys (Fig. 86.6D), we prefer the dismembered technique because it provides more flexibility. During the conduct of the pyeloplasty, care must be taken to avoid inadvertent division of small vessels to the parenchyma and excessive dissection of the ureter or pelvis. As much adventitial tissue is left on the ureter as possible, and no vessels to the ureter are sacrificed unless their division is necessary to provide for adequate mobilization.

After the proximal ureter and renal pelvis are adequately exposed using sharp dissection, two stay stitches of 5-0 chromic are positioned in the ureter just below the UPJ (Fig. 86.6). The ureter is divided between these stitches and carefully mobilized. A pelvic flap is then created by orienting a wide-based inverted V-shaped incision on the renal pelvis, with the apex of the inverted V at the UPJ. The flap is designed such that it will provide a dependent portion of pelvis for the anastomosis. It is important that the base of the V be wide to avoid ischemia of the flap. The flap is opened with tenotomy scissors and the tip is trimmed minimally to smooth the point of the V. The ureter is then positioned so the length and position of the spatulation can be judged. The spatulation is positioned on the posterior aspect of the ureter using Potts scissors such that the ureter will not be twisted when it is laid on the dependent pelvic flap. It is critical that the flap and the spatulated ureter are approximated in a tension-free fashion. If the repair is performed under tension, an anastomotic stricture may result.

It is also important that the upper ureter or anastomosis is not compressed by any of the renal vessels, as they may obstruct the repair (13). The anastomosis and dissection are performed with the aid of 2.5× optical magnification. We perform the anastomosis using 7-0 Vicryl in younger children and 6-0 Vicryl in adolescents.

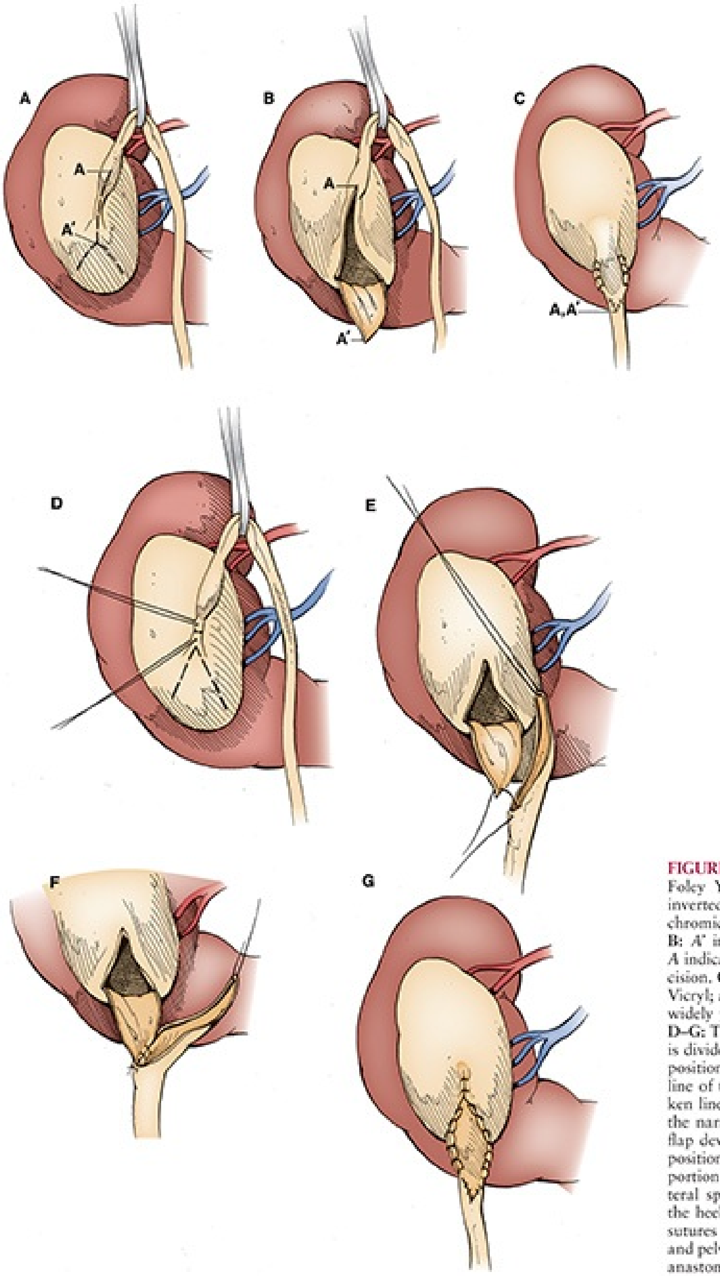

FIGURE 86.6 Pyeloplasty techniques. A–C: The Foley Y-V technique. A: Broken lines indicate inverted Y-shaped incision. Stay sutures of 5-0 chromic help define the margins of the incision. B: *A'* indicates the tip of the renal pelvic flap. *A* indicates the inferior margin of the ureteral incision. C: *A* and *A'* are sutured together with 7-0 Vicryl; as the remainder of the repair is closed, a widely patent dependent anastomosis is created. D–G: The dismembered technique. D: The ureter is divided distal to the UPJ after stay stitches are positioned. The inverted V, indicating the outline of the pelvic incision, is indicated by a broken line. E: The ureter has been spatulated after the narrowed segment is excised and the pelvic flap developed. The initial stitch of 7-0 Vicryl is positioned to approximate the most dependent portion of the pelvic flap to the heel of the ureteral spatulation. F: Interrupted sutures around the heel are completed. G: The running locking sutures extending between the spatulated ureter and pelvis are completed, creating a widely patent anastomosis.

The fact that the ureter is dismembered and freely mobile allows the surgeon to position it so that the ureteral spatulation can extend into a relatively wide portion of the ureter and simultaneously the ureter can be oriented to avoid torsion or redundancy that might kink the ureter distal to the repair. The anastomosis in the dismembered pyeloplasty seems technically easier than the Foley Y-V because the ureter is not fixed at two points.

We begin the anastomosis at the heel, suturing the most dependent portion of the V-shaped incision to the apex of the ureteral spatulation. The initial portion of the anastomosis is performed using interrupted sutures, in general, one at the apex and two on either side of the apex. Each stitch must be precisely positioned to avoid postoperative leakage and/or compromise of the lumen. After the apex is anastomosed, the remainder of the pyeloplasty is performed using a running locking 7-0 Vicryl suture up one side of the spatulated ureter and then up the other side. Prior to complete closure, the patency of the anastomosis is tested by passing a 5Fr and 8Fr feeding tube through the repair. No stent or diversion is in general employed in children. A Penrose drain is positioned near the anastomosis and made to exit through a separate stab wound. The abdominal wall closure is performed using running 3-0 or larger polydioxanone suture (PDS). We close the skin with a subcuticular pull-out stitch of 3-0 Prolene. Most children are discharged the day after surgery. The skin suture is removed between 6 and 8 days postoperatively, and the drain is removed at that time if drainage is minimal.

Ureterocalicostomy

A ureterocalicostomy is usually performed to salvage a failed prior pyeloplasty, but it can be considered as the primary procedure for UPJ obstruction when there is a small intrarenal pelvis or in other instances with significant lower pole caliectasis and thin overlying parenchyma (13) (Fig. 86.7). This can be performed either via an open approach or laparoscopically with or without robotic assistance (14). When the open technique is employed, the ureter is carefully separated from the pelvis as described earlier, and if feasible, a pyelotomy is performed. We find that a finger inserted into the open renal pelvis and positioned in the lower pole calyx aids in the dissection. The parenchyma over the dilated lower pole calyx is incised with electrocautery; the capsule is incised and the parenchyma resected to allow adequate exposure of the calyx. Hemostasis is achieved using cautery and/or sutures of 4-0 chromic through the edge of the resected parenchyma. The ureter is spatulated and the anastomosis between the ureter and the opened calyx is performed as described in the figure. We divert the urine by using a nephrostomy tube (a 10Fr or 12Fr Malecot catheter) and either a ureteral stent (usually a 5Fr feeding tube) or a double-J stent. A ureterocalicostomy as it would appear in a horseshoe kidney is shown in Figure 86.8.

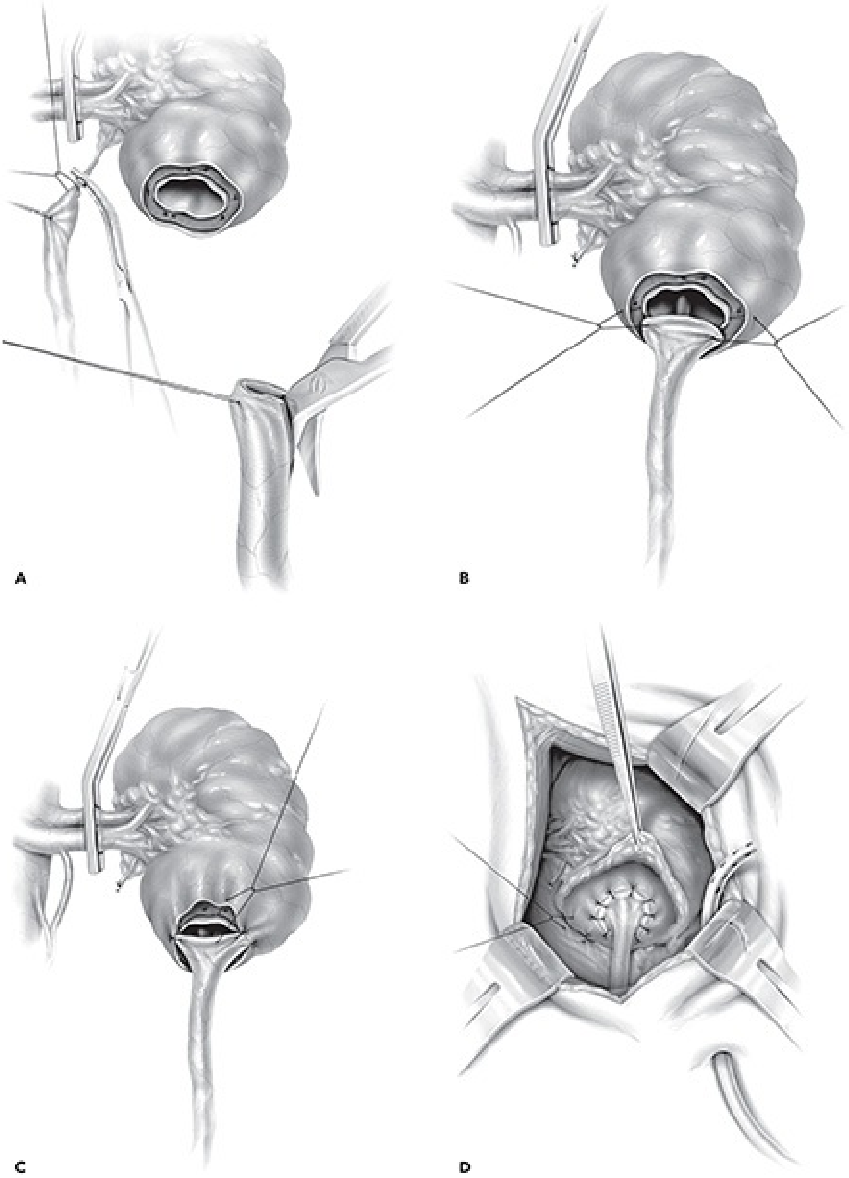

FIGURE 86.7 Ureterocalicostomy for correction of ureteropelvic obstruction after a prior failed pyeloplasty. **A:** The scarred ureter is divided and spatulated widely. Thin cortex over the dilated lower pole calyx has been excised and hemostasis achieved. **B:** The spatulated ureter is anastomosed to the open lower pole calyx. The sutures of 4-0 chromic catch the capsule, calyx, and ureter (the end of a double-J stent is visualized in the pelvis). **C:** The anastomosis is completed with interrupted sutures. A nephrostomy tube (not visualized) should be used. The surgeon may irrigate through the nephrostomy tube to ensure a watertight repair. **D:** Place one or two nephropexy sutures to obviate kinking of the repair. Replace the perirenal fat and place a perinephric drain. (Modified with permission from Steffens J, Humke U, Haben B, et al. Open ureterocalycostomy. *BJU Int* 2008;101[3]:397–407. Copyright © 2008, John Wiley and Sons.)

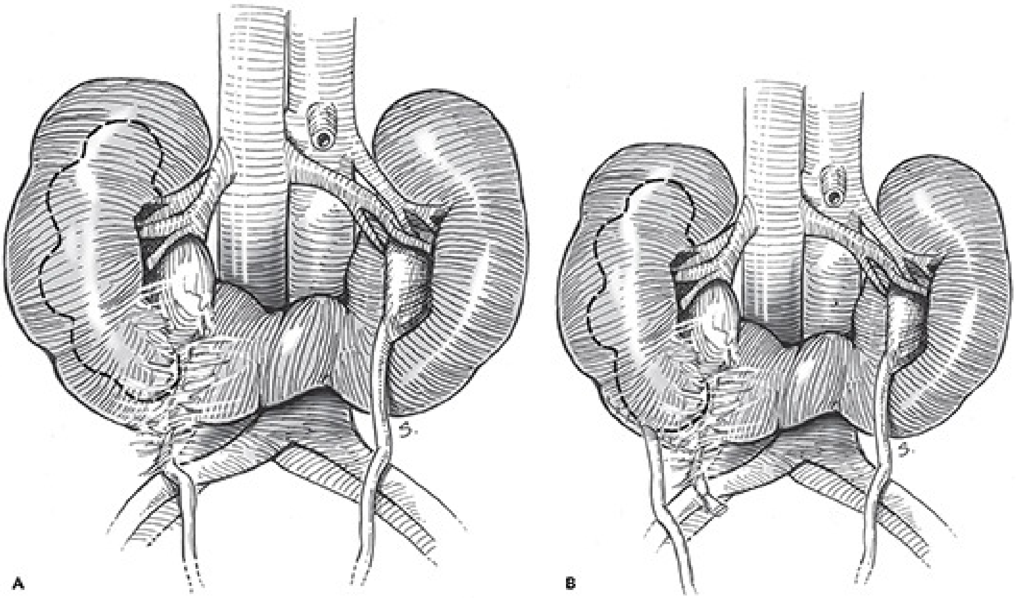

FIGURE 86.8 **A:** Horseshoe kidney with prior failed pyeloplasty; note the dilated intrarenal collecting system. **B:** After ureterocalicostomy, dependent drainage has been achieved. (Modified with permission from Kay R. Ureterocalicostomy as a salvage procedure. *Urol Times* 2001;April:34. Copyright © 2014 Advanstar Communications, Inc. All rights reserved. Reproduction in whole or in part is prohibited.)

Surgery for Tumors

Renal cell carcinoma and renal pelvic tumors are reported in horseshoe kidneys (15). Wilms tumor occurring in a horseshoe kidney represented 0.48% of tumors in the National Wilms Tumor Study; this incidence is about twice that expected in the general population (16). When Wilms tumor involves a horseshoe kidney, the involved portion of the kidney and isthmus are generally resected in the course of removal of the tumor. If the tumor occurs in the isthmus, some authors have recommended bilateral lower pole heminephrectomy. If the Wilms tumor is bilateral at presentation, management is the same as for bilateral Wilms tumors in orthotopically positioned kidneys.

Tumor surgery of the horseshoe kidney deserves special mention because excision of the involved kidney will necessitate division of the isthmus. If the isthmus is composed of a band of fibrous tissue, it can be readily divided using cautery; however, if it is functioning parenchyma, it must be carefully addressed to avoid excessive blood loss and necrosis of the remaining parenchyma, with the risk of secondary bleed and urinary fistula. The area must be carefully dissected and arteries to the isthmus sequentially occluded with bulldog clamps to assess the line of demarcation. Once this line is established, the capsule is divided sharply and the parenchyma divided. Bleeding from the cut parenchyma is controlled with 4-0 chromic sutures. Any exposed calices are closed with running locking 4-0 or 5-0 chromic sutures, and the capsule and parenchyma are closed with carefully positioned horizontal mattress sutures of 2-0 chromic (Fig. 86.9).

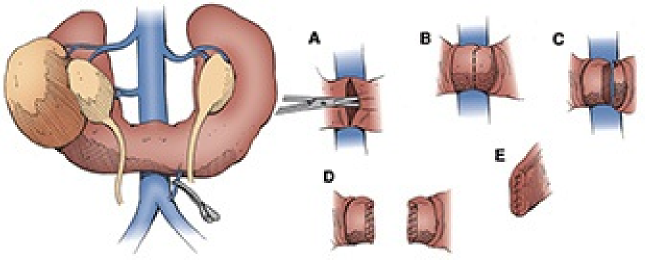

FIGURE 86.9 Division of the isthmus of a horseshoe kidney with a right-sided renal tumor. The isthmus blood supply is from the left iliac. **A:** After identification of the line of demarcation, an incision is made around the capsule of the isthmus. **B:** The capsule is peeled back. **C:** The parenchyma of the isthmus is transected in a wedge fashion to facilitate closure. **D:** Horizontal mattress sutures of absorbable 2-0 material are used to close the parenchyma for hemostasis. **E:** The capsule is closed over the parenchyma with a continuous absorbable suture.

Stone Surgery in the Horseshoe Kidney

Pyelolithotomy had been utilized in past decades to clear calculi from horseshoe kidneys, but currently, percutaneous and extracorporeal techniques are employed almost exclusively. Extracorporeal shock wave lithotripsy (ESWL) in the horseshoe kidney has not enjoyed the success rate that it provides in orthotopically positioned kidneys. Most series note the requirement for an increased number of shocks, an increased need for retreatment, and a somewhat decreased stone clearance rate in horseshoe kidneys compared to stones in normally positioned kidneys. One series recorded a 73% stone-free rate in horseshoe kidneys using ESWL after multiple treatments (17). One of the reasons for difficulties treating stones with ESWL is that the anterior position of the stone makes it harder to position the stone at the F2 focus; often, the surgeon will have to employ the blast path to try to fragment the stone. Some investigators have used prone positioning to overcome this problem.

Alternatively, percutaneous endoscopic treatment of calculi in horseshoe kidneys is safe and effective. After appropriate CT planning, percutaneous access to the horseshoe kidney is best achieved using an upper pole posterior calyx. Stones in any calyx can be managed through this access, although often a long nephroscope and flexible instrumentation are required (18,19). Reports comparing ESWL of stones in horseshoe kidneys to percutaneous nephrostolithotomy conclude that the percutaneous technique provides superior stone clearance rates (18). One series reported an 82% overall stone-free rate when treating staghorn calculi with percutaneous nephrolithotomy (20).

A final option for management of stones in the horseshoe or ectopic kidney is via a transperitoneal pyelolithotomy via laparoscopic approach (21). This approach is safe and feasible with the added benefit of allowing for removal of intact stones, which may decrease stone recurrence (22).

When calculus disease complicates obstruction of the UPJ in a horseshoe kidney, the stone is removed at the time of pyeloplasty. In these instances, there may be considerably more reaction around the pelvis and ureter, so the use of a nephrostomy tube and ureteral stent is prudent. An antegrade study can be performed 10 to 12 days postoperatively prior to nephrostomy tube removal to confirm drainage through the UPJ and integrity of the repair.

Robotic Pyeloplasty for Ectopic Kidneys

Technique

The technique for robotic-assisted laparoscopic pyeloplasty (RALP) has been described by Lee et al., and robotic pyeloplasty for horseshoe or ectopic kidneys can be performed in a similar fashion with adjustments in port placement, robot location, and patient positioning as needed depending on the location of the renal pelvis (23). It is worth noting that RALP in these abnormal kidneys provides the additional advantage of allowing improved visualization of the surrounding operative field.

Briefly, the technique for robotic pyeloplasty for pelvic kidney in children is described in the following text (Fig 86.10). Following optional cystoscopy with retrograde ureterograms and double-J stent placement, a bladder catheter and placement of a nasogastric tube and rectal tube are inserted and the patient is secured to the table in the supine position to allow for lateral rotation as well as head down positioning. The child’s feet should be positioned at the end of the table. A tall child or adult can be positioned in the lithotomy position. This allows the robot to be brought in from the foot of the bed. Alternatively, the patient can be positioned in the flank position, and the robot can be positioned at the side of the bed in instances where the kidney is located higher in the pelvis. The child is then prepped from the anterior thigh to the nipple line and to the posterior axillary line on either side and draped in the usual sterile fashion.

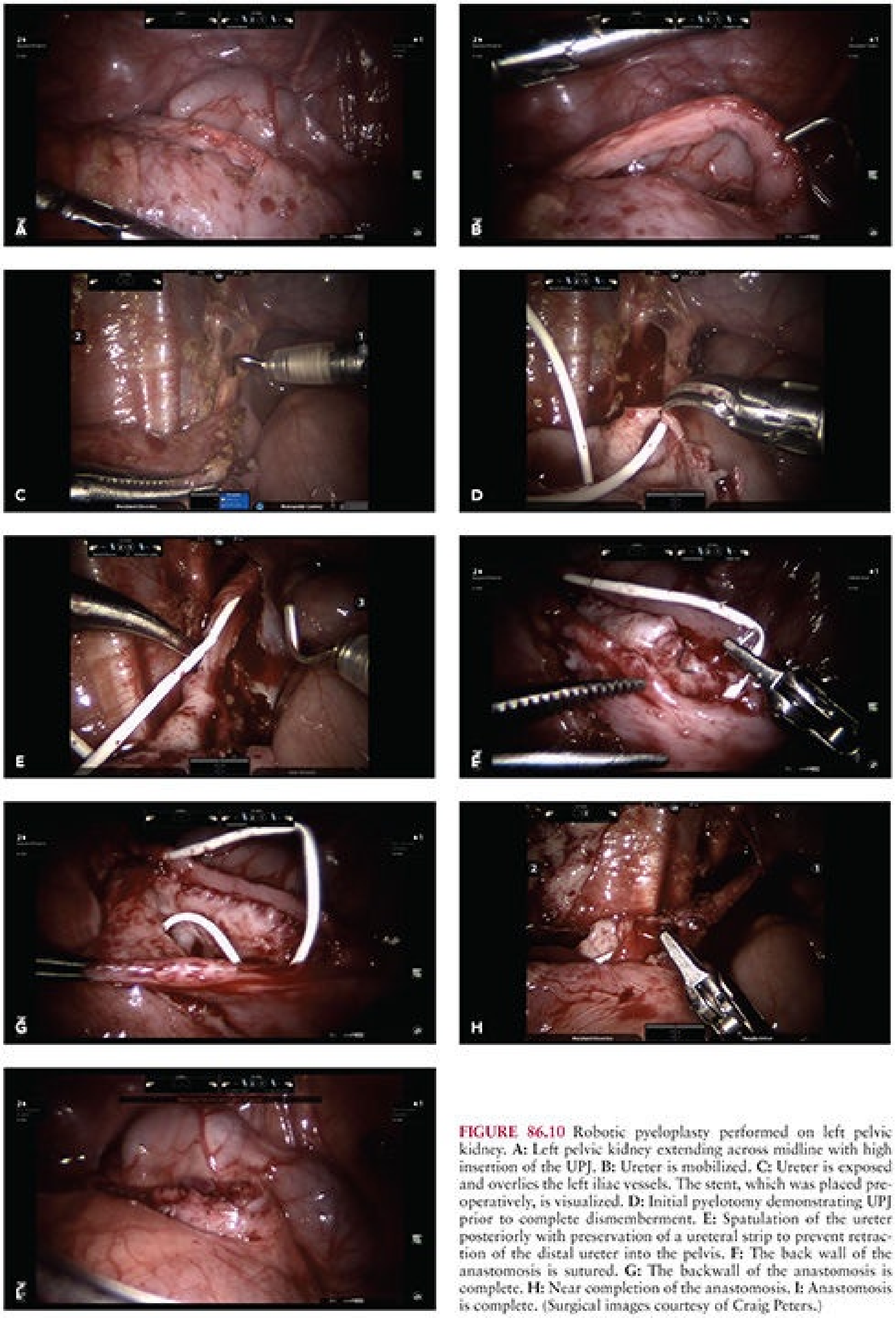

FIGURE 86.10 Robotic pyeloplasty performed on left pelvic kidney. **A:** Left pelvic kidney extending across midline with high insertion of the UPJ. **B:** Ureter is mobilized. **C:** Ureter is exposed and overlies the left iliac vessels. The stent, which was placed preoperatively, is visualized. **D:** Initial pyelotomy demonstrating UPJ prior to complete dismemberment. **E:** Spatulation of the ureter posteriorly with preservation of a ureteral strip to prevent retraction of the distal ureter into the pelvis. **F:** The back wall of the anastomosis is sutured. **G:** The backwall of the anastomosis is complete. **H:** Near completion of the anastomosis. **I:** Anastomosis is complete. (Surgical images courtesy of Craig Peters.)

First, the 8-mm or 12-mm camera port is inserted using an open Hasson technique in the inferior fold of the umbilicus. The camera is inserted, and the peritoneal cavity is inspected following appropriate insufflation. Under direct visualization, two working ports, either 5-mm or 8-mm, are inserted lateral to the umbilicus approximately four fingerbreadths away from midline. Following the port incisions, 2-0 Vicryl U-stitch fascial sutures are placed at each site for easy postprocedure closure of all port sites (24). The table is then rotated and the patient is placed in the head-down position to allow the intestines and colon to fall away from the kidney. The robot is brought from the foot of the bed and the arms are engaged to the ports.

Dismembered pyeloplasty is performed via transperitoneal approach similar to that as described by Lee et al. (23). Briefly, hook electrocautery and graspers are used for mobilization and dissection (Fig. 86.10A–C). The colon is either mobilized medially and cephalad to expose the renal pelvis and ureter which are then mobilized. Cold scissors are used to incise the pelvis parallel to the ureter, and the ureter is spatulated for a side-to-side anastomosis (Fig. 86.10D and E). The excised pelvis tissue/tissue at level of UPJ can serve as a handle for retraction and thus grasping of the ureteral tissue that has been spatulated is limited. The anastomosis is carried out using 5-0 or 6-0 Monocryl suture in an interrupted or running fashion (Fig 86.10F and G). If a double-J stent was not placed preoperatively, a large angiocatheter can be placed through the anterior abdominal wall, and a wire and double-J stent can be placed in an antegrade fashion down the ureter. Following placement of several initial sutures, the excess ureteral and pelvis tissue is excised. With the stent in place, the pelvis anastomosis is completed (Fig. 86.10H).

Surgical Options for the Ectopic Kidney

The ectopic kidney can be affected by any of the processes that occur in a normally positioned kidney. Overall, the evaluation and surgical management of these conditions will follow the lines of those discussed with horseshoe kidney. Vesicoureteral reflux, if it mandates operative treatment, is addressed by a standard ureteral reimplantation or, alternatively, subureteral injection of a bulking agent.

On occasion, one has to address the problem of a failed pyeloplasty in a patient who has an ectopic pelvic kidney. Ureterocalicostomy is one alternative in management of this problem; another is the use of a pyelovesicostomy. Pyelovesicostomy has been performed in renal transplant recipients after ureteral loss due to ischemia and/or rejection and has proven to be a viable salvage procedure.

OUTCOMES

Complications

Complications of pyeloplasty, such as prolonged urine leakage and poor anastomotic drainage, occur somewhat more frequently in horseshoe kidneys than in normal kidneys. The risk of renal ischemia caused by damage to an aberrant vessel is increased in the horseshoe or ectopically positioned kidney.

Results

Pyeloplasty in the horseshoe kidney is in general a successful procedure. A higher rate of complications was experienced in the era when division of the isthmus was employed.

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CHAPTER 87 TRANSURETEROURETEROSTOMY

AARON D. MARTIN AND H. GIL RUSHTON

Ureteral surgery and various conditions, including trauma, stricture, neoplasm, or a previous failed surgical procedure, can render a ureter inadequate for successful ureteroureterostomy or ureteroneocystostomy. Transureteroureterostomy (TUU), first described by Higgins (1) in the 1930s, has gained increased prominence in pediatric urology as a method to compensate for a lacking or defective distal ureter. In some cases, bridging the midureter to the contralateral ureter via TUU may salvage a renal unit, especially in cases when an ipsilateral psoas hitch and/or Boari flap are insufficient to accomplish this task. In other situations, TUU can be performed as a salvage procedure following previous failed ureteral surgery (2,3). More recently, TUU has been employed in complex reconstructive procedures that entail harvesting of the distal donor ureter for alternative purposes, including augmentation ureterocystoplasty or as a continent catheterizable conduit (2).

DIAGNOSIS

In the majority of cases in pediatric urology, TUU is employed as part of a planned reconstruction. The preoperative workup requires thorough assessment of bilateral renal function and drainage, knowledge of the anatomy of both the donor and recipient ureters, and careful evaluation of bladder function. Differential renal function and drainage are most objectively determined by preoperative MAG-3 renal scintigraphy. Sonography can aid in determining the presence and severity of hydronephrosis. Contrast imaging with intravenous, retrograde, or antegrade pyelography may be necessary in select cases when detailed anatomic definition of the ureters is required. Contrast voiding cystography is the best modality to assess for the presence of vesicoureteral reflux, which, when present, provides a "free" retrograde ureteropyelogram. In cases involving children with abnormal or neuropathic bladder function, preoperative urodynamics is required to evaluate bladder capacity, compliance, and emptying.

Less commonly in children than in adults, initial recognition of a ureteral injury requiring a TUU occurs intraoperatively during resection of a tumor or during exploration for trauma. Fortunately, in the majority of these cases, one can usually anticipate a normal recipient ureter and bladder.

INDICATIONS FOR SURGERY

The primary goal of a TUU is to reestablish nonobstructive, nonrefluxing drainage of the ureter. Historically, TUU in children has been performed either to salvage a failed ureteral reimplantation or in conjunction with cutaneous ureterostomy for urinary diversion (4–6). Because TUU requires only one ureter for reimplantation, this procedure was commonly employed in the 1980s for urinary undiversion of conduits or in the construction of continent urinary reservoirs (3,7). In the majority of these cases, TUU was used simultaneously with reimplantation of the recipient ureter, many of which required tapering or tailoring frequently with a psoas hitch and/or bladder augmentation. TUU has also been used as an adjunct to reimplant procedures complicated by an abnormal bladder, which precludes reimplantation of more than one ureter, or as a salvage procedure for failed ureteral reimplantation surgery (3). More recently, indications for TUU have been broadened to allow for harvesting the distal donor ureter to construct a continent ureteral conduit for clean intermittent catheterization or for unilateral ureterocystoplasty in cases where there is sufficient ureteral dilatation (2).

Ureteral reconstruction with TUU may not be possible if there is insufficient donor ureter (approximately one-half the original length) for a tension-free anastomosis. Any disease process that has the potential to affect contralateral renal function or drainage is also a contraindication, such as retroperitoneal fibrosis, high-dose radiation therapy, calculus disease, recurrent pyelonephritis, and urothelial malignancy. Although size disparity between ureters has been regarded as a relative contraindication in the past, successful TUU has been accomplished by use of a longer vertical ureterotomy in the recipient ureter to accommodate a larger-caliber donor ureter (3,5,7).

ALTERNATIVE THERAPY

Other procedures to be considered in lieu of TUU include ureteroneocystostomy with a psoas hitch or Boari flap, nephropexy to allow ureteroneocystostomy or ureteroureterostomy, ileal substitution, and autotransplantation. Other alternatives to TUU include mitigating or temporizing procedures such as cutaneous ureterostomy, pyelostomy, nephrostomy drainage, and ureteral stenting. Nephrectomy should also be considered in cases of marginal donor renal function.

SURGICAL TECHNIQUE

The patient is placed supine with such options as kidney rest elevation, retroflexion of the surgical bed, and Trendelenburg positioning to enhance retroperitoneal exposure. A midline vertical incision is usually made in the abdomen, extending from just above the umbilicus to the pubic symphysis. However, in cases of distal TUU following a failed reimplantation, a Pfannenstiel incision may be sufficient. A choice of exposure approaches is then available.

Transperitoneal Approach

Wide transperitoneal exposure is indicated in cases that require complex adjunct procedures such as tapered reimplantation of the recipient ureter or bladder augmentation as well as when there is a long segment of diseased distal donor ureter. This approach would also be preferred when a high TUU is necessary for the distal donor ureter to be used as a continent catheterizable channel or for augmentation of the bladder.

The bowel is packed and retracted superiorly to allow for further dissection. Once the ureters have been visualized as they pass over the iliac vessels, two options for opening the retroperitoneum have been described (8): (a) two 5-cm vertical incisions may be made over the ureters where they cross the iliac vessels, creating a window on each side (Fig. 87.1), and (b) wider retroperitoneal exposure can be achieved through a single curved incision that opens the retroperitoneum from over the left distal ureter, extending across the midline along the small bowel mesentery and cecum and up the right side along the line of Toldt (Fig. 87.2). This technique allows for more extensive mobilization of the bowel in an upward direction.

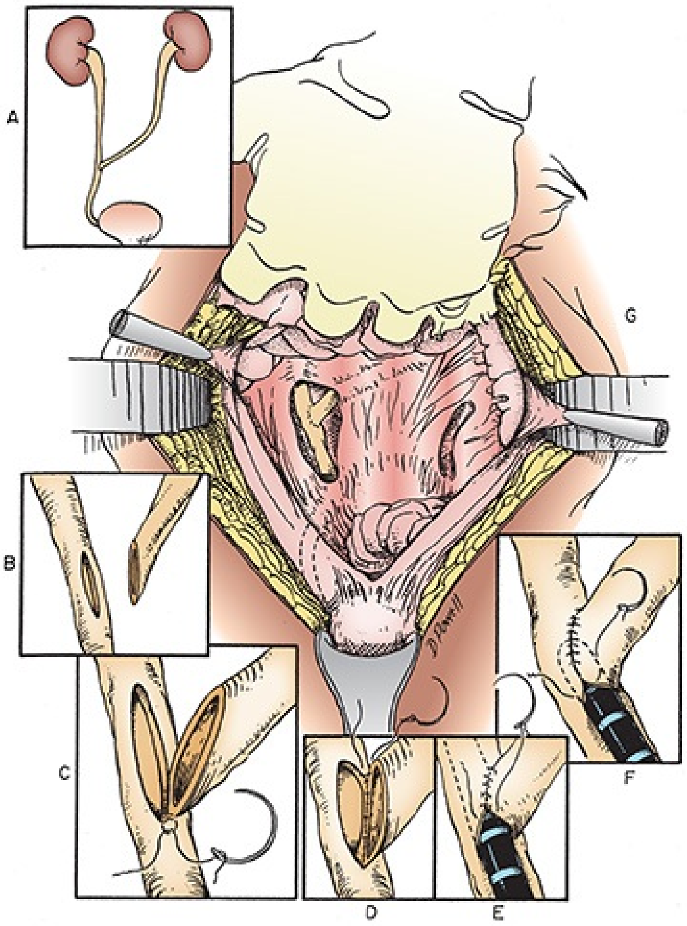

FIGURE 87.1 TUU approached by two incisions in the posterior peritoneum. **A:** Schematic diagram of left-to-right TUU. **B:** The donor ureter is approximated to the vertical ureterotomy on the anteromedial aspect of the recipient ureter. **C and D:** The anastomosis is begun at the apex and is extended to the posterior aspect of the TUU, using either running or interrupted absorbable sutures. **E and F:** The anterior aspect of the anastomosis may be performed over a catheter or feeding tube removed prior to the last stitch. **G:** Completed TUU in situ.

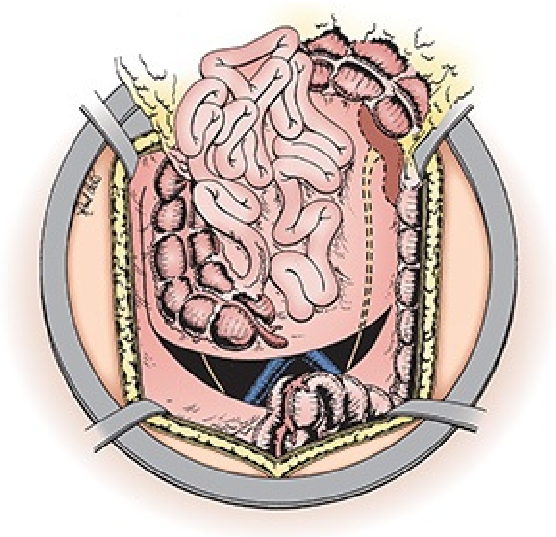

FIGURE 87.2 Approach for single curvilinear incision in the posterior peritoneum to mobilize the bowels and mesentery and expose the retroperitoneum.

Once the ureters are adequately exposed, the retroperitoneal tunnel is created by blunt dissection beneath the posterior peritoneum, anterior to the great vessels and superior to the inferior mesenteric artery (IMA). The angle between the aorta and IMA may kink or even obstruct the donor ureter. The position of the IMA should therefore be noted and avoided in calculating the path of the donor ureter to the contralateral retroperitoneum. Rarely, it may be necessary to ligate the IMA to prevent donor ureteral compression.

Retroperitoneal Approach

This technique provides the benefit of preventing complications associated with intraperitoneal procedures. The author prefers this approach for a more distal TUU, which requires less mobilization of the donor ureter. Other authors have also described this method as a viable alternative to the transperitoneal approach (9). Most commonly, this approach would be used in salvage procedures for failed ureteral reimplantation.

After the transversalis fascia is incised, the extravesical space is mobilized on each side of the bladder. The ureters are identified crossing beneath the obliterated umbilical arteries. After dividing these vessels with Vicryl or silk ties, the peritoneal sac is retracted superiorly to further expose the retroperitoneum. The peritoneal sac may also be reflected medially to expose the area of interest.

Once adequate exposure of the ureters has been achieved, blunt finger dissection is then used to create an ample retroperitoneal tunnel. In cases of a low TUU using a retroperitoneal approach, the tunnel is created beneath the posterior peritoneum just superior to the posterior wall of the bladder and anterior to the sacral promontory.

Transureteroureterostomy

Adjunct procedures required for the recipient ureter, such as tapering and reimplantation, should be undertaken prior to the anastomosis of the donor and recipient ureter. For a standard TUU, mobilization of the donor should be sufficient to create a tension-free anastomosis. Because preservation of blood supply is essential for the success of TUU, great care is taken to avoid unnecessary disruption of the adventitia. The ipsilateral gonadal vessel may be tied off with a 3-0 silk suture to provide even greater mobilization with adventitial preservation. If even greater donor ureteral length is necessary, the donor kidney may be gently mobilized, moved inferiorly, and pexed to the psoas muscle using interrupted 3-0 Vicryl or 3-0 polydioxanone sutures.

After dividing the donor ureter as distal as possible, a long tagged 4-0 chromic or Vicryl suture is then placed on the most distal aspect of the divided donor ureter to allow the ureter to be brought through the retroperitoneal tunnel. A right-angle clamp can then be passed from the recipient to the donor side to grasp the stay suture on the donor ureter and pull the donor ureter through the tunnel. Care must be taken to avoid twisting or kinking of the ureter, and the ureter should reach easily to the other side without tension.

With respect to the recipient ureter, mobilization should be minimized. To enable touch-free manipulation of the recipient ureter, stay sutures consisting of 4-0 or 5-0 chromic may be placed in the recipient ureteral adventitia, superior and inferior to the intended area of anastomosis. A vertical ureterotomy at least 1.5 cm in length on the anteromedial wall of the recipient ureter is then performed at the site of the anastomosis. The donor ureter is then spatulated to accommodate the recipient ureterotomy. However, spatulation may not be necessary if the donor ureter is sufficiently dilated. The anastomosis is performed using interrupted (Fig. 87.3) or running 4-0 or 5-0 absorbable sutures, beginning with the superior and inferior apices, followed by the approximation of the more posterior wall of the anastomosis. At this juncture, a ureteral catheter or infant feeding tube may be helpful in some cases to facilitate the anterior wall anastomosis. This tube may be removed just prior to the final anastomotic stitch (see Fig. 87.1).

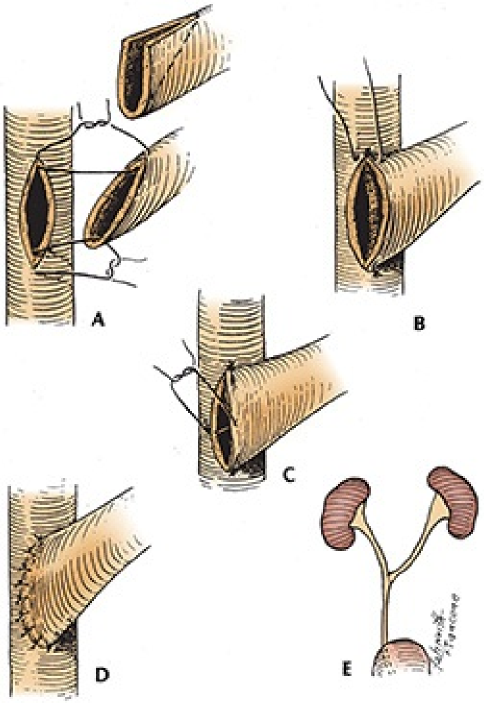

FIGURE 87.3 TUU anastomosis performed with interrupted absorbable sutures. **A and B:** After aligning the distal donor ureteral lumen and recipient ureterotomy, apical sutures are placed and tied. **C:** Subsequent intervening interrupted sutures are placed halfway between previously placed sutures. **D:** Completed anastomosis. **E:** Schematic diagram of completed TUU.

The use of an indwelling ureteral stent is mandatory only when the recipient ureter distal to the anastomosis has been altered in some fashion, such as in reimplantation. A 5Fr or 8Fr feeding tube or a double-J stent may be used. In addition, nephrostomy drainage of the recipient ureter may be employed if extensive mobilization or tapering of the recipient ureter and/or kidney is required to complete the reconstruction (3). In all cases, it is vital to drain the retroperitoneal space using either a Penrose or closed suction drain. Furthermore, with the transperitoneal approach, it is recommended to close the posterior peritoneum to avoid drainage of urine into the peritoneal cavity. Finally, a suprapubic catheter or urethral catheter should be placed to keep the bladder decompressed, as an overly distended bladder in the early postoperative period may stress the TUU anastomosis.

Approximately 2 months postoperatively, the patient should undergo a renal sonogram and/or a diuretic renal scan to assess drainage and/or renal function. Depending on the results, imaging may be repeated in 3 to 9 months until a trend of progression has been established. Renal function by creatinine measurements should also be followed, particularly if these levels were elevated preoperatively.

Laparoscopic/Robot-Assisted Approach

Laparoscopic TUU has recently been described in children (10). Initially, cystoscopy is performed for a retrograde pyelogram with stent and/or wire placement. The patient is then placed supine and redraped. After gaining periumbilical access to the peritoneal cavity, working ports (3 to 5 mm) are placed under laparoscopic vision in the hypogastrium and in the right and left anterior axillary line. The position is adjusted according to patient size and the level of the expected donor ureter transection but typically at the level of the umbilicus or higher. The patient is placed in the Trendelenburg position with the donor ureter side elevated 30 to 45 degrees and the surgeon standing on the contralateral side.

The donor ureter is exposed and dissected distally by incising the peritoneum at the pelvic brim. The dissection is carried down to the bladder, taking care not to damage the vas deferens in males. The ureter is transected at the level of the bladder obliquely and the distal stump/bladder is closed with an absorbable suture. The donor ureter is further mobilized proximally while maintaining ample periureteral vascularization. The surgeon can then switch to the patient’s opposite side and roll the table to elevate the recipient ureter side to aid in preparation of the recipient site at the pelvic brim in a similar fashion.

Using blunt dissection, a rectosigmoid mesenteric window can be created through which to pass the donor ureter. A stay suture or atraumatic grasper can be used to facilitate this transfer. It is critical that the donor ureter is not compressed, twisted, or kinked in the tunnel and reaches the recipient site easily without tension. Otherwise, further proximal dissection is necessary. Next, a medial longitudinal ureterotomy is made in the recipient ureter corresponding to the size of the donor ureter lumen. The recipient ureteral stent can be left in place and used to aid in visualization of the anastomosis. The anastomosis can be accomplished with two running 5-0 absorbable monofilament sutures. A drain can be left via one of the port sites near the anastomosis if desired. The Foley catheter can be removed on postoperative day 1 or 2 with the drain to follow after the patient has voided and there are no concerns for leakage. Typically, the ureteral stent is removed 2 to 4 weeks after surgery.

Although no reports of robot-assisted laparoscopic transureteroureterostomies have been published to date, certainly the same technique described earlier can be applied with the advantage of increased dexterity when suturing the anastomosis. Either a three-port or four-port technique can be used with the optional fourth port used for an assistant port or the fourth robotic arm for help with retraction and passing the ureter through the tunnel. Alternatively, a pure laparoscopic approach can be used for ureteral mobilization and transposition with the robot brought in strictly for the anastomosis while using the same trocar arrangement.

OUTCOMES

Complications

Postoperative complications include urinoma, pyelonephritis, prolonged anastomotic drainage, and stricture (11). The risk of any of these complications is heightened by tenuous ureteral blood supply from excessive mobilization or from previous radiation (12). Patients with neuropathic or abnormal bladders may be more at risk for developing new vesicoureteral reflux or distal ureteral stenosis in cases that involve reimplantation of the recipient ureter (13). Early anastomotic obstruction leading to persistent drainage may be initially treated conservatively with placement of a double-J ureteral stent or percutaneous nephrostomy.

Late complications include small bowel obstruction but only in cases involving the transperitoneal approach. A TUU performed in the context of neoplasm may suffer from late ureteral obstruction. Subsequent stone disease can potentially obstruct the common segment, rendering the patient anuric and mandating emergent percutaneous nephrostomy drainage or ureteral stenting. Rarely, compression of the donor ureter by the IMA can develop years after TUU if precautions to avoid the artery during donor ureter tunneling were not taken. However, despite potential problems and the possible need for reoperation, several series have shown that TUU anastomotic revision is rarely, if ever, necessary. Also, donor renal loss due to chronic infection or obstruction has proven infrequent, with rates ranging from 0% to 6% (2,3,5). Recipient kidney loss is even less common, reportedly occurring only after extensive mobilization required in complex reconstructions (3,7).

Results

Numerous studies have shown excellent results after TUU. Damage to the recipient kidney and ureter has rarely been observed, and successful preservation of both renal units occurs in >90% of cases. TUU performed in the correct setting, with meticulous attention to maintaining ureteral blood supply and a tension-free anastomosis, is clearly an important component of the urologist’s repertoire of reconstructive ureteral surgery.

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CHAPTER 88 PYELOPLASTY

MEGAN S. SCHOBER, KEVIN M. FEBER, AND EVAN J. KASS

Improved antenatal ultrasonography techniques have clearly been a factor in identifying collecting system dilation in the neonatal period. Obstruction is not necessarily the cause of hydronephrosis in the neonate; however, ureteropelvic junction (UPJ) obstruction is the most common cause of significant renal pelvis dilation in this age group (1). An exact etiology of UPJ obstruction has yet to be determined, but multiple hypotheses exist as to the cause of the obstruction. Incomplete recanalization of the proximal ureter, functional or anatomic obstruction, and developmental arrest are a few theories as to why obstruction occurs at the UPJ. Although the etiology of the obstruction may be unknown, the classification of obstruction can be divided into three categories: intrinsic, extrinsic, and secondary. Intrinsic UPJ obstruction is usually characterized by a stenotic or adynamic segment of ureter. Less commonly, intrinsic obstruction can be caused by mucosal folds or “flaps” (2). It has been estimated that 60% to 80% of persistent hydronephrosis in infants is secondary to intrinsic obstruction. Extrinsic obstruction most often occurs from an aberrant crossing vessel typically traveling to the lower pole of the kidney. This is a more common presentation in older children and adults. Secondary obstruction is rarer than extrinsic or intrinsic obstruction. It occurs when the ureter is severely dilated and tortuous from vesicoureteral reflux causing a “kink” in the ureter that acts as an impediment to urine flow. Over time, this area can become the site of significant periureteral scarring requiring surgical correction.

DIAGNOSIS

Before routine prenatal ultrasonography, the most common presentation of an infant with UPJ obstruction was with a palpable abdominal mass. Prenatal ultrasound has significantly increased the number of infants diagnosed with asymptomatic hydronephrosis. Prior to maternal ultrasonography, children with UPJ obstruction presented later in childhood with flank pain, hematuria, recurrent urinary tract infections, abdominal mass, or urolithiasis. Extrinsic compression of the UPJ by crossing vessels is more commonly seen in older children and accounts for the second peak of UPJ obstruction diagnosis in later childhood and adolescents. These children are usually diagnosed after multiple episodes of periodic flank pain accompanied by nausea and vomiting. Neonates with a history of antenatal hydronephrosis should undergo postnatal renal ultrasound. If prenatal hydronephrosis was unilateral and mild to moderate, postnatal renal ultrasound should be performed at 1 to 2 weeks of life because transitory dehydration of the newborn usually lasts about 48 hours after birth and can underestimate the degree of hydronephrosis visualized. However, if the hydronephrosis detected prenatally was severe, bilateral, or associated with oligohydramnios, postnatal ultrasound should not be delayed. When the diagnosis of hydronephrosis has been confirmed postnatally, a voiding cystourethrogram (VCUG) is typically performed to exclude vesicoureteric reflux as the cause and also to determine if there are any other associated findings.

Once the diagnosis of UPJ obstruction is suspected after completion of renal ultrasound and VCUG, a diuretic renal scan is the next study that should be performed. Mercaptoacetyl triglycine (MAG-3) with furosemide is the preferred test in this situation to determine relative renal function and if delayed drainage is present. There has been much debate regarding the use of calculated half-times in response to furosemide administration and half-time should not be the sole determining factor in the clinical decision-making process regarding UPJ obstruction (3).

INDICATIONS FOR SURGERY

Indications to proceed to pyeloplasty at our institution include the following: severe hydronephrosis (Society for Fetal Urology grade III or IV) detected postnatally accompanied by <40% differential renal function with no response to furosemide on renal scan, worsening hydronephrosis on serial ultrasound, symptomatic UPJ obstruction, loss of relative renal function on serial renal scans (>10%), or persistent delay in drainage on serial diuretic renography in a child with severe hydronephrosis.

ALTERNATIVE THERAPY

Multiple treatment options currently exist for the treatment of UPJ obstruction ranging from endopyelotomy to robotic pyeloplasty. At this time, endopyelotomy is not commonly performed in neonates and infants but has been used in preadolescent and adolescent children with some degree of success. It has also been demonstrated that endopyelotomy appears to be more successful as a secondary technique for failed pyeloplasty in children. However, more recent data suggest that redo pyeloplasty or ureterocalicostomy are more successful secondary treatments than endourologic procedures (4,5).

Pure laparoscopic or robotic-assisted laparoscopic pyeloplasty has gained significant popularity in the last decade, as the success rates, operative times, and hospital length of stay of these procedures are becoming comparable to open pyeloplasty (6,7). Robotic assistance has significantly decreased the learning curve for minimally invasive pyeloplasty by making intracorporeal knot tying a much simpler process. Although robotic pyeloplasty in small infants has been shown in the literature to be a successful operation, the open Anderson–Hynes pyeloplasty continues to be the gold standard for clinically significant UPJ obstruction in neonates and small infants with reported success rates consistently >90% to 95%. The most important factors in a successful pyeloplasty of any technique include formation of a funnel at the UPJ with dependent drainage and a tension-free anastomosis.

SURGICAL TECHNIQUE

The patient is placed in the flank position using a rolled towel and/or table flexion with elevation of the kidney rest depending on the size of the child (Fig. 88.1). Incision is made in a transverse fashion medial to the tip of the 12th rib and carried anteriorly. Subcutaneous tissues and musculofascial layers are opened with electrocautery (Fig. 88.2). The lumbodorsal is divided and the peritoneum is swept medially taking care to remain extraperitoneal. Gerota fascia is then identified and opened.

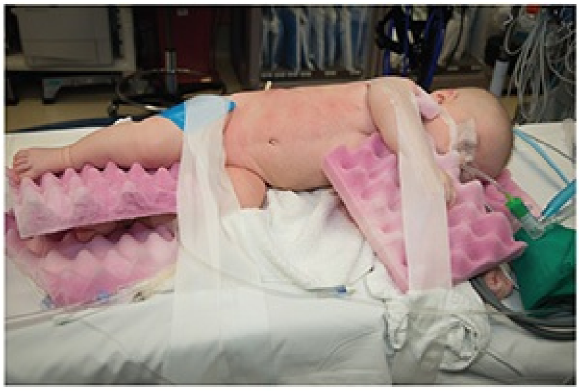

FIGURE 88.1 Surgical positioning for open pyeloplasty in flank position.

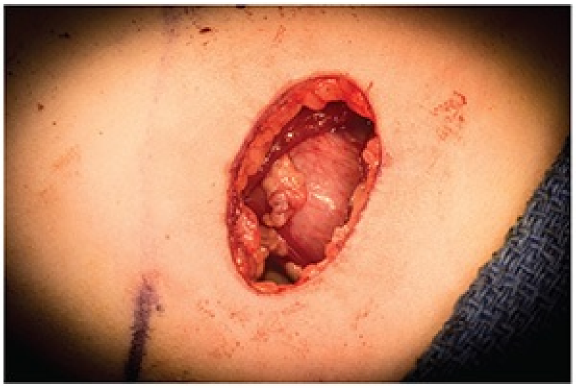

FIGURE 88.2 Flank incision medial to the tip of the 12th rib.

Once Gerota is entered, the lower pole and renal pelvis should be identified and the UPJ should be sharply dissected (Fig. 88.3). At this point, one should be able to determine the etiology of the obstruction. Care should be taken to preserve the blood supply to periureteral tissues and the ureter. Stay sutures are placed cephalad to the UPJ and in the ureter to minimize manipulation of the ureteral tissues. The renal pelvis is incised circumferentially at the UPJ to decompress the collecting system (Fig. 88.4). The proximal ureter is then mobilized and the atretic segment is identified and excised. Excessive trimming of the renal pelvis is avoided but can be performed in the case of a severely redundant pelvis. The proximal ureter is then spatulated and assessed to ensure that the ureter is healthy appearing (Fig. 88.5). A 5Fr feeding tube is then inserted into the ureter to begin the ureteropelvic anastomosis. Anastomosis is performed at the most dependent portion of the renal pelvis with interrupted polydioxanone suture (PDS) (Fig. 88.6). Running suture can be used; however, placing interrupted sutures decreases the likelihood of the suture "bunching up" and causing subsequent narrowing of the anastomosis. In infants, we use 7-0 PDS. Extreme care is taken to avoid any twisting or kinking of the anastomosis. Optical magnification with a 3.0× to 4.5× loupe facilitates precise suture placement. If there is any remaining pelvis tissue open after suturing the anastomosis, it is closed with running 6-0 PDS suture (Fig. 88.7).

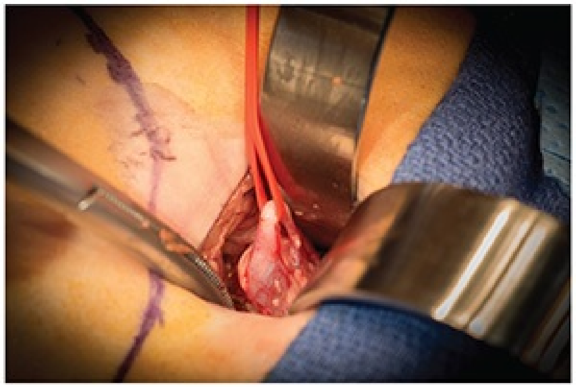

FIGURE 88.3 Ureteropelvic junction identified by a red vessel loop.

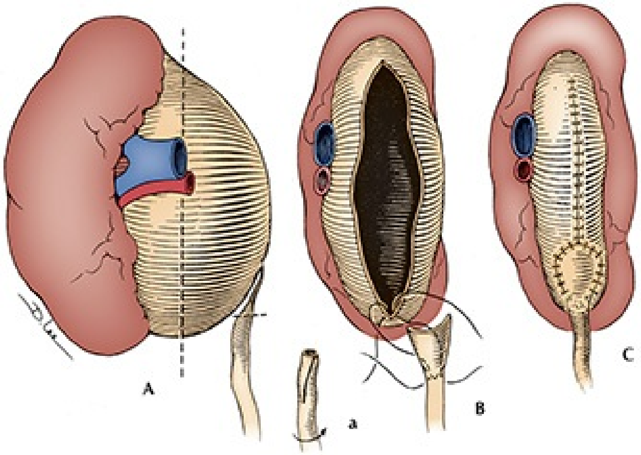

FIGURE 88.4 Dismembered pyeloplasty. **A:** The renal pelvis is incised, redundant tissue excised, and the ureter divided distal to the atretic segment. **B:** The ureter is spatulated and brought to the most dependent portion of the pelvis. **C:** The remaining pelvis is closed with running sutures.

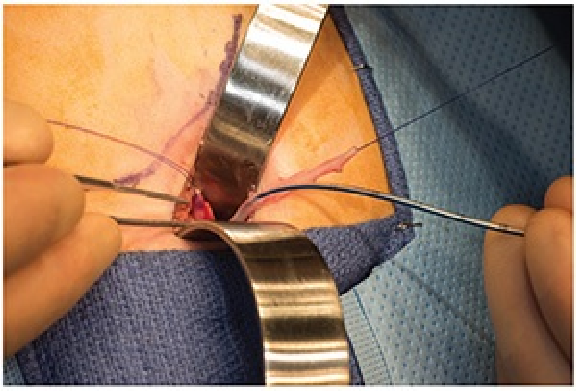

FIGURE 88.5 Proximal ureter is spatulated; feeding tube placed into ureter.

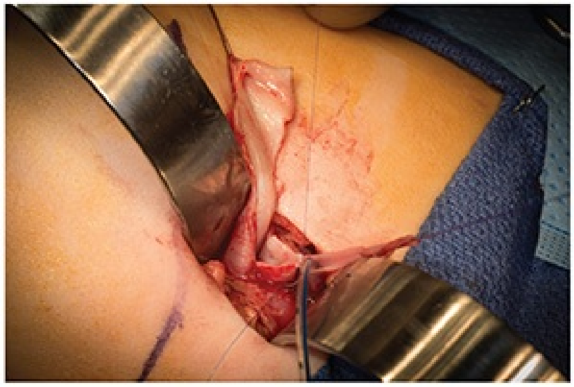

FIGURE 88.6 Anastomosis of spatulated ureter to renal pelvis with 7-0 PDS.

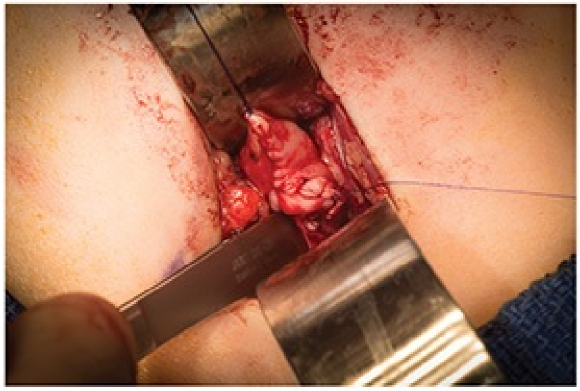

FIGURE 88.7 Completed repair.

Of note, if the UPJ obstruction is found to be secondary to a crossing vessel, the divided ureter is brought anterior to the vessel, and the ureter and pelvis are anastomosed in this anterior location (Fig. 88.8).

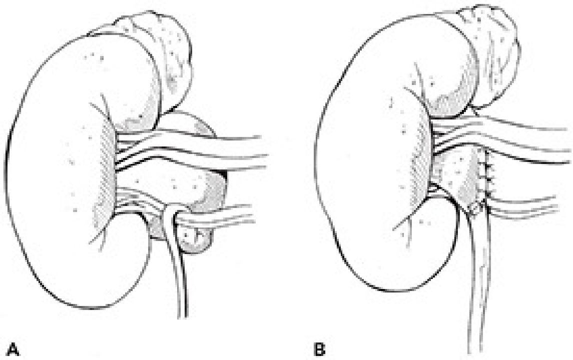

FIGURE 88.8 Dismembered pyeloplasty with accessory vessels. A: Vessels causing ureteral compression and hydronephrosis. B: Anastomosis performed anterior to crossing vessels. Pelvic tailoring as needed.

A 0.25-inch Penrose drain is placed in the perirenal space and brought out through the skin in a separate more caudal puncture (Fig. 88.9). The musculofascial layers are closed with 3-0 polyglactin suture. Subcutaneous tissues reapproximated with 4-0 plain gut suture and the skin is closed with a running subcuticular 5-0 poliglecaprone suture.

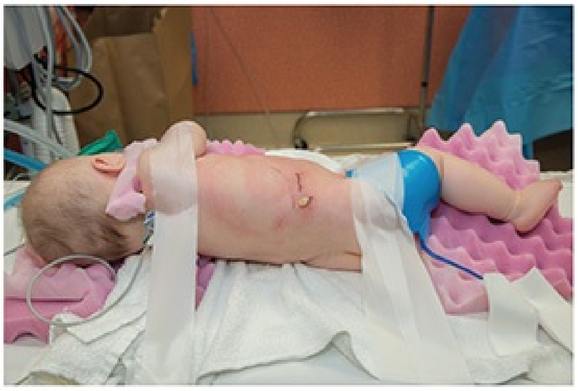

FIGURE 88.9 Completed procedure showing positioning, incision, and Penrose drain.

The use of ureteral stents and nephrostomy tubes continue to be a controversial issue and is surgeon-dependent. At our institution, we generally do not use a stent or nephrostomy tube. Indications for ureteral stenting include solitary kidney, renal insufficiency, extensive renal pelvis tailoring, or those undergoing redo pyeloplasty. Disadvantages of ureteral stenting or nephrostomy tube usage include patient discomfort and stent removal in the operating room under a second anesthetic. A nephroureteral catheter such as a Pippi Salle stent allows removal in the office, thus avoiding a second anesthetic. These stents can be removed as early as 1 to 2 weeks postoperatively. If a double-J ureteral stent is used, removal in the operating room is generally recommended 4 to 6 weeks after surgery.

Postoperatively, the patients are kept on intravenous antibiotics until the Penrose drain is removed, which typically occurs on postoperative day 1 or 2 if there is no evidence of a urinary leak. If high drain output is observed or if there is clinical concern for delayed urinary leak, we advocate leaving the Penrose drain in place for 1 to 2 weeks. Pain is controlled with ketorolac 0.25 mg per kg for the first 24 to 48 hours. We have found that narcotic pain medications are rarely needed when ketorolac is used. Children are typically discharged home within 24 hours of surgery. Follow-up renal ultrasound is performed 4 weeks postoperatively. MAG-3 renal scan is performed after pyeloplasty if there is clinical evidence of continued obstruction or no improvement in hydronephrosis postoperatively. If MAG-3 demonstrates loss of renal function, early intervention such as percutaneous nephrostomy drainage or ureteral stenting should be considered to avoid further renal damage.

OUTCOMES

Complications

As with any type of operation, bleeding is always a risk of this procedure. Although very rare, when significant bleeding occurs, it is typically from an aberrant vessel. This complication can be avoided by careful dissection and identification of any abnormal anatomy during the procedure. Retroperitoneal leaks can occur but usually resolve spontaneously. If the leak persists, antegrade or retrograde stenting can be useful. Other complications after open pyeloplasty include obstruction associated with lack of improvement in renal washout as well as diminished renal function. Fortunately, these complications are rare but will require a second surgical procedure such as ureterocalicostomy or redo pyeloplasty.

Results

At our institution, we have found open dismembered pyeloplasty to be curative for UPJ obstruction in >95% of our patients.

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CHAPTER 89 MEGAURETER

CHRISTOPHER J. LONG, J. CHRISTOPHER AUSTIN, AND DOUGLAS A. CANNING

Megaureter is a relatively rare congenital anomaly of the urinary tract. We define a megaureter as having a diameter that is 8 mm or greater. The upper limit width for a normal ureter in a full-term newborn is 7 mm. Megaureter is a broad term and is further subdivided into four categories: (a) refluxing; (b) obstructed; (c) both refluxing and obstructed; and (d) nonobstructed, nonrefluxing megaureter. The Pfister-Hendren classification stratifies the ureter based on appearance: in type I, dilation is limited to the distal ureter with no pelvic dilation; type II involves dilation of both the ureter and the pelvis; and type III has severe dilation of the ureter and pelvis with tortuosity of the ureter. Further, megaureters can be either primary or secondary; secondary causes of megaureter include posterior urethral valves, high-volume vesicoureteral reflux, neuropathic bladder resulting in higher detrusor pressure, or less commonly an acquired condition such as external compression of the ureter from a mass lesion or retroperitoneal fibrosis. Primary megaureters, in contrast, are isolated physical abnormalities of the ureter or ureterovesical junction resulting in a dilated ureter.

Prior to the widespread use of screening prenatal ultrasonography, most children with megaureters presented with urinary tract infection, flank pain, urolithiasis, abdominal mass, or hematuria. Most cases today are detected in asymptomatic infants with hydroureteronephrosis in utero. This earlier presentation has led to changes in the approach to management.

The pathophysiology of obstructive megaureters lies not within the dilated segment of the ureter but in the distal, nondilated segment. This segment of ureter is characterized by a deficiency in muscle fiber cross-linking and increased collagen deposition, although this segment is not usually narrowed compared with the normal ureter. These changes compromise the ureter’s ability to effectively propagate the urine bolus as it descends toward the bladder. When the bolus of urine encounters the aperistaltic segment, only a portion of the urine passes into the bladder; the remainder ascends back up the ureter in a yo-yo fashion. This process constantly repeats itself and results in the characteristic appearance of fusiform dilation in which the distal ureter is more severely affected. Proximal dilation and hydronephrosis may develop when the amount and force of the bolus are sufficiently large that it dilates the entire ureter and reaches the renal pelvis.

DIAGNOSIS

The primary goal when evaluating a megaureter is to distinguish an obstructed megaureter from the nonobstructed entities. These ureters demonstrate a spectrum of severity rather than separate conditions. The diagnostic workup depends on the presenting signs and symptoms and may vary from patient to patient. For the child with prenatal hydroureter (width 8 mm or above), the usual evaluation includes a renal/bladder ultrasound, a voiding cystourethrogram (VCUG), and a renal scintigram (renal scan) depending on the degree of dilation. Hydroureteronephrosis is identified with the renal ultrasound. Severe hydronephrosis warrants antibiotic prophylaxis upon initial diagnosis and should be continued for at least 6 to 12 months if no surgical intervention occurs. The dilated ureter is usually visible in the pelvis and is posterolateral to the bladder. If the ureter is dilated inferior to the level of the trigone, an ectopic ureter may be present rather than a primary megaureter with a pseudoureterocele visualized in the bladder. The VCUG separates children with refluxing megaureters from those without reflux and will identify a ureterocele if present. The renal scan in the newborn should be performed with mercaptoacetyl triglycine (MAG-3) with diuretic washout. The scan will estimate the relative function of each kidney and measure the effectiveness of renal clearance of radiotracer from the collecting system. In the past, the $t_{1/2}$ (time required for half of the radiotracer to clear from the renal pelvis) had been used as an indicator of obstruction. However, in practice, the use of the $t_{1/2}$ alone to estimate obstruction is not always reliable and can be delayed simply by the presence of a dilated ureter or pelvis. Because the clearance is variable based on the patient's prestudy hydration level, age, renal function, and response to the diuretic, we prefer to follow trends in the relative renal function, reserving surgery for those with increasing $t_{1/2}$ or decreasing relative renal function. A differential renal function of <40% or a change in split function >10% should be considered clinically significant.

In children who are symptomatic, the presenting symptom(s) determines the subsequent workup. Hematuria, rarely noted in children with megaureter, is normally evaluated initially with a renal/bladder ultrasound. The finding of hydroureteronephrosis should be followed by a renal scan or intravenous pyelogram. If there is suspicion of renal or ureteral stone, a noncontrast computerized tomography scan should be performed. The renal scan may be required to provide a baseline estimate of relative renal function. If the anatomy is unclear, magnetic resonance urography (MRU) can identify both aberrant anatomy and differential function and can help distinguish between an obstructed megaureter and an ectopic ureter.

If there is impaired function of the affected kidney and the child is undergoing surgical correction, cystoscopy should be performed at the beginning of the reconstructive procedure to evaluate the position of the ureteral orifice. The orifice is normally positioned in an obstructed megaureter, whereas an ectopic ureter will distort the trigone and an ectopic orifice can often be visualized in the urethra.

INDICATIONS FOR SURGERY

Relative indications to proceed with surgical repair include poor initial relative function (<40% of differential renal function by renal scan), progressive hydronephrosis, decreasing function (>10%) in serial renal scans, persistent severe hydroureteronephrosis, bilateral megaureters, or failure of conservative management (the development of symptoms such as pain localized to the side of the megaureter or febrile urinary tract infection). In older children with megaureter, we tend to operate on those who present with symptoms of intermittent flank pain or urinary tract infection.

In infants with indications for intervention, we consider alternative approaches given the infant's small, thin-walled bladder and the technical difficulties of reimplanting a large, hydronephrotic ureter into the small infant bladder. Options in these patients include endoscopic stenting, a staged reconstructive approach with temporary diversion to an end-cutaneous ureterostomy, and construction of a refluxing ureteral reimplantation, or, rarely, diverting pyelostomy should be given consideration instead of primary surgical repair (1,2).

Prior to surgery, we evaluate the child for voiding dysfunction. Rarely, children develop a secondary megaureter from high-pressure bladder storage that is transmitted to the ureter and renal pelvis. Ureteral dilation can be detected in association with neuropathic bladder dysfunction, posterior urethral valves, or severe voiding dysfunction. Appropriate treatment of the posterior urethral valves or the bladder dysfunction may result in improvement or resolution of ureteral dilation. Dysfunctional bowel elimination can have a significant impact on bladder emptying and should be assessed in every patient evaluated for dysfunctional voiding. Failure to recognize bladder and bowel dysfunction before surgical intervention increases complication rates including persistent obstruction or vesicoureteral reflux.

ALTERNATIVE THERAPY

Because most patients are asymptomatic and identified on prenatal ultrasound, the great majority of children with primary megaureters do not require surgical correction. Ureteral dilation does not always indicate obstruction. Dilation in some boys and girls may represent the residuum of in utero obstruction that has resolved. The long-term experience at the Children's Hospital of Philadelphia (CHOP) has been that the majority of children with megaureter maintain renal function and ureteral dilation often improves with time, albeit with close observation for renal function preservation. In a series of 27 children with megaureters treated conservatively with a mean follow-up of 6.8 years, hydronephrosis completely resolved in 53% and was improved or stable in the rest. Only 10% of patients required surgical correction, while 90% were followed with serial radiologic studies. A single patient from this cohort developed progression of hydronephrosis and diminished function at age 14 (3). Likewise, in a series of 53 patients with 67 megaureters, only 17% required surgery for poor initial function or progressive loss of function; in addition, the dilation completely resolved by ultrasound in 34% (4). These two series are concordant with additional literature on primary ureter management and suggest that the majority can be managed conservatively. Because of the rare risk of late progression of obstruction, we recommend that all children with persistent hydronephrosis have extended follow-up.

ENDOSCOPIC TECHNIQUES

One option that deserves consideration is double-J stent insertion with or without dilation of the diseased segment via either endoscopic balloon dilation or laser incision. Cystoscopy is performed to evaluate the appearance of the ureteral orifice. Retrograde pyelogram is performed to assess the area of narrowing and the proximal ureter. If balloon dilation is performed, the ureter is intubated with a 14Fr endoscopic balloon and inflated to 14 atmospheres for 3 minutes. For narrowing that extends beyond 2 cm, a ureteroscope can be inserted to perform laser incision of the ureter at the 12 o'clock position, followed by balloon dilation of the ureter. A double-J stent is left in place for 2 months postoperatively. One additional option is double stenting of the ureter, with the theory that the constant sliding of the stents against one another allows the ureter to heal at a wider caliber.

The endoscopic approach has several advantages. It can be performed as an outpatient procedure and if failure occurs, a formal reimplant remains an option although some groups have reported inflammation and subsequent ureteral scarring after stent placement. Its use in infants younger than 1 year of age has increased, acting to temporarily relieve the obstruction until bladder growth allows for a more definitive formal reimplant.

SURGICAL TECHNIQUE

The surgical correction is similar for refluxing and obstructed megaureters. Obstructed megaureters have a distal ureteral segment of variable length with a normal or narrowed caliber that does not contract normally and should be excised. Refluxing megaureters are dilated to the level of the ureterovesical junction. Distal segment excision is not always required.

The child is positioned supine on the operating room table. In boys, the lower abdomen and genitalia are fully prepped and draped. Females are placed in a mild frog-legged position with gel bolsters under the knees to permit intraoperative access to the urethra if needed. The bladder may be left full during the initial surgical exposure. A Pfannenstiel incision is made in the abdominal skin crease. The rectus fascia is opened transversely along the course of the incision and the flaps of fascia are elevated off the muscle superiorly to just below the umbilicus and inferiorly to the pubis. The rectus muscles are separated in the midline. The space of Retzius is entered, exposing the bladder.

Intravesical Approach

At this point, depending upon the surgeon’s preference, the dissection of the ureter begins either intravesically or through an extravesical exposure. It has been our preference to begin intravesically. The bladder is opened via a midline cystotomy. The bladder dome is packed with damp sponges and a Dennis–Brown retractor is placed to provide exposure of the trigone. A 5Fr feeding tube is passed up the ureter and secured at the orifice with a 4-0 suture. The urothelium surrounding the orifice is divided using electrocautery. With the mucosa divided circumferentially, the ureteral catheter is gently pulled to expose the medial and inferior attachments of the trigonal musculature. These attachments are divided with electrocautery. At this point, the dissection proceeds to carefully divide the muscular attachments of the ureter through the plane of Waldeyer sheath. This dissection will free the distal ureter, which should have a normal or narrowed caliber. The surgeon should recognize the blood supply of the ureter, as shown in Figure 89.1. As the dissection proceeds more proximally, the blood supply of the ureter originates from medial branches of the hypogastric (male) or cervical (female) arteries. These vessels should be preserved, as should the longitudinal blood supply, by taking care to prevent dissection too close to the ureteral wall. When the ureter is free from its intramural attachments, the mobilization should proceed extravesically. The ureter at this point can be passed through the bladder wall, and the dissection proceeds more proximally. When the dilated region of the ureter is reached, dissection should continue until an adequate length for reimplantation has been mobilized, again paying attention to preserving the blood supply. An ischemic distal ureter may lead to fibrosis and obstruction.

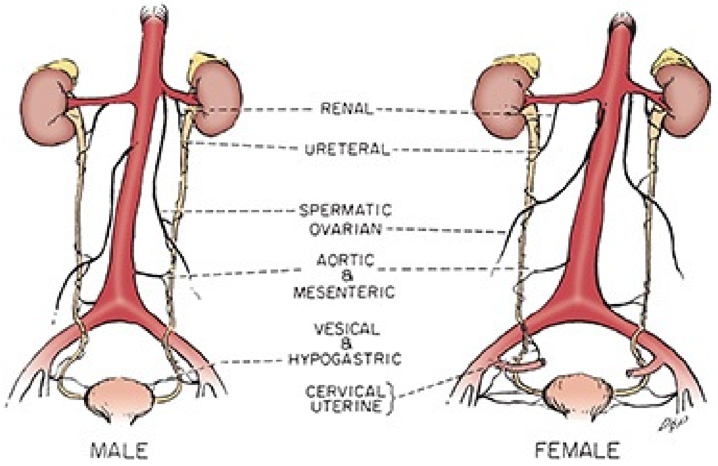

FIGURE 89.1 Major arterial supply to the ureter. It is not necessary to sacrifice any medially based blood supply for primary megaureter repair.

At this point, the surgeon must decide whether to taper the ureter. In general, if the lumen of the ureter is significantly larger than 10 mm, it should be tapered prior to reimplantation. This improves reimplant effectiveness by achieving an appropriate ratio of tunnel length to ureteral width. There are two techniques used to taper the size of the ureter: (a) excisional tapering and (b) tapering by folding. We will review the three most commonly used procedures. The goal of tapering is to provide a distal ureter with a small enough diameter that postoperative vesicoureteral reflux will be prevented with a reasonable length of intramural tunnel. The tapering needs to extend for only a short distance beyond the bladder wall rather than the whole length of the ureter. The dilation of the proximal ureter should improve postoperatively with the relief of obstruction and/or reflux. The decision to perform an excisional versus a folding technique depends on the preference of the surgeon and the size and thickness of the ureter. Folding a very dilated, thick-walled ureter will leave a large amount of residual bulk, making the creation of the submucosal tunnel difficult. In general, the taper should not be aggressive. In a bladder that functions well, reflux is less hazardous than persistent obstruction. In general, an intravesical reimplant should be pursued when a ureter meets criteria for tapering.

Excisional tapering (Fig. 89.2) begins with careful examination of the ureter. Without twisting the ureter, the surgeon observes the pattern of blood supply to the ureter. In most cases, the longitudinal vessels are predominately located along the medial aspect of the ureter. Usually, the excised segment of ureter is taken from the opposite side along the lateral border. The distal nondilated ureteral (aperistaltic) segment is excised. A 12Fr catheter is passed up the ureter. With this in place, the wedge to be excised is identified and outlined. Aggressive tailoring may result in obstruction and should be avoided. The process of excising and suturing the ureter will result in considerable contraction of the ureteral lumen. The tailored segment should gradually widen as the ureter is reconstructed proximally. The ureter is then closed. The mucosa and the muscularis of the ureter are closed with absorbable interrupted or running fine suture. A second layer if desired may incorporate the muscularis and adventitia with a series of interrupted absorbable fine sutures. The ureter is then reimplanted in a cross-trigonal fashion. If possible, the ureteral suture line should be positioned facing the detrusor muscle to prevent the development of a ureterovesical fistula and reflux. The 12Fr catheter is replaced with a 5Fr or 8Fr feeding tube or a double-J stent. The advantage to leaving an open-ended ureteral catheter is that a retrograde ureteral study can be performed postoperatively to demonstrate ureteral drainage, and the catheter can be removed in the office. The internal stent is easy to care for and leaves the patient free of external tubes; however, it requires a general anesthetic for removal. All tapered reimplants should be stented, regardless of which type of stent is used.

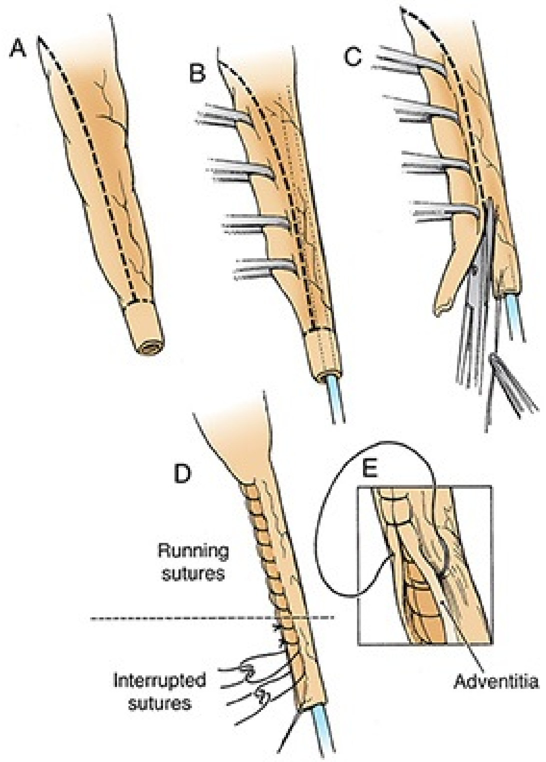

FIGURE 89.2 A and B: The wedge of ureter to be excised is secured with Allis or Hendren clamps. C: The outlined segment of ureteral wall is excised sharply. D and E: The ureter is closed in two layers. Distally, interrupted sutures are placed to allow for trimming of the end of the ureter at the time of reimplantation.

There are two techniques commonly employed for tapering by ureteral folding: (a) the Starr plication and (b) the Kaliscinski technique. Both techniques are similar to excisional tapering with regard to the length of ureter to be narrowed and the choice of the segment of the wall based upon the intrinsic blood supply. Starr plication (Fig. 89.3) reduces the diameter of the ureter by infolding the ureteral wall with interrupted Lembert sutures of 5-0 polyglyconate or polydioxan. The tapering begins proximally and gradually reduces the caliber of the ureter until the diameter approaches that of the 12Fr catheter. Care should be taken to ensure the wedge of folded ureter stays in the same position of the ureteral wall as you proceed distally and does not spiral from lateral to medial as the sutures are placed more distally. The ureter is reimplanted with the plication sutures facing the detrusor muscle as described with excisional tapering. The Kaliscinski technique (Fig. 89.4) begins with a running horizontal mattress suture of 5-0 or 6-0 chromic that runs the length of the segment to be tapered, creating a defunctionalized wedge of ureter that is then wrapped around the ureter and secured posterior with interrupted absorbable sutures. The ureter is reimplanted with the imbricated segment against the muscularis. Again, ureteral stents are placed in both repairs as with excisional tapering.

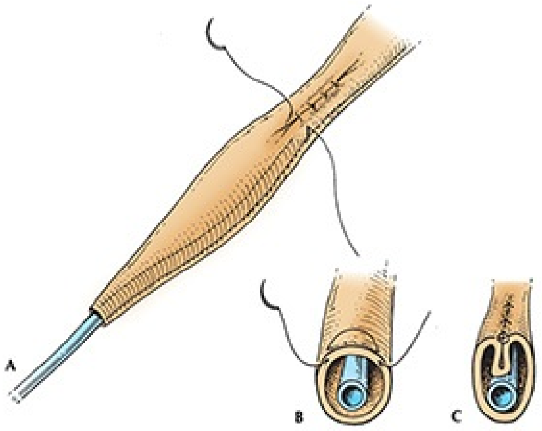

FIGURE 89.3 A: Starr plication of the ureter suture to infold the ureter. B: Cross section to show placement of Lembert-type sutures. C: Cross section after ligation of sutures.

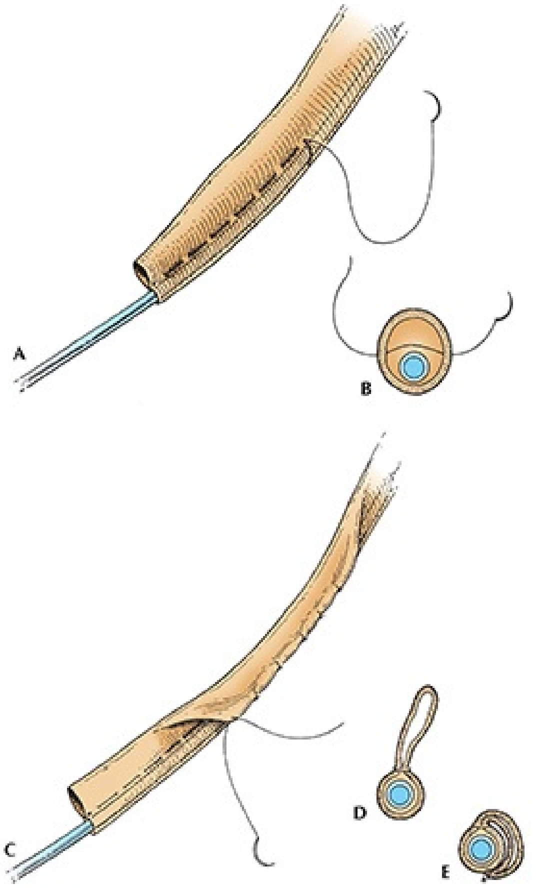

FIGURE 89.4 Kaliscinski technique of ureteral imbrication. A: Placement of cobbler's stitch to exclude a major portion of the ureteral lumen. B: Same in cross section. C: After ligation. D: Excluded portion of the ureter is folded over and wrapped around the intubated ureter. E: Final appearance in cross section.

Extravesical Approach

Several authors have reported good results with the extravesical approach to megaureter repair (5,6). We avoid this technique in bilateral megaureter. In cases of bilateral megaureters, a high rate of voiding dysfunction postoperatively has been reported that may require intermittent catheterizations for a period following surgery. A Foley catheter is placed at the beginning of the procedure. The catheter may be attached with a Y-connector for intraoperative filling and emptying. The ability to regulate the bladder volume aids in the dissection. The incision and initial approach is identical as for the intravesical approach until the bladder is exposed. The dissection then proceeds into the lateral extravesical space. The obliterated umbilical artery is divided to expose the ureter. The ureter is carefully dissected free and encircled with a vessel loop. The ureter is dissected distally to the ureterovesical junction. With the bladder full, a detrusorotomy is made in a line extending from the bladder neck cephalad and circumscribing the detrusor adjacent to the ureter. The length of the incision should be 3 to 4 cm.

The ureter is freed from all detrusor attachments, keeping the mucosal attachments intact. The edges of the detrusor incision are then dissected free of the urothelium to form flaps that can be closed over the ureter. If the urothelium is perforated during the dissection, it can be repaired with 6-0 or 7-0 chromic. The most distal region is ligated and the ureter divided proximal to the ligature. The aperistaltic segment of the ureter is resected. The dilated ureter is then tapered as necessary. An indwelling stent is placed if the ureter is tapered. The bladder is partially emptied and the ureter is then directly anastomosed to the urothelium at the distal apex of the detrusorotomy using 5-0 absorbable sutures. With this accomplished, this advancement stitch fixes the distal ureter to the detrusor with 5-0 polyglyconate horizontal mattress sutures at the apex. The detrusor is then closed over the ureter with 4-0 polydioxan sutures. The hiatus should be approximated but not closed too tightly. A Foley catheter is left indwelling postoperatively and a Penrose drain is placed during closure.

Robotic Reimplant

The robotic approach has reached nearly all facets of intra-abdominal surgery within pediatric urology. Its use in ureteral reimplant for vesicoureteral reflux has made dismembered reimplant for an obstructed megaureter an easy transition. Positioning is either supine or dorsal lithotomy, dependent on patient size. Taller children require the lithotomy position to allow robot docking from the foot of the bed. All pressure points are padded with gel pads and tape is placed across the chest and midthigh to prevent patient migration during the procedure. Cystoscopy is performed and an internal double-J stent is placed. Pneumoperitoneum in the pediatric population should be obtained via an open technique. A semicircular incision is hidden within the umbilicus and an 8.5-mm Hassan trocar is inserted as a camera port. Two additional 5-mm robotic trocars are placed under direct vision on either side of the umbilicus along the midclavicular line. We prefer to use the 5-mm ports with the Maryland and the hook cautery. Alternatively, 8-mm robot ports can be used for larger children or if the surgeon prefers to use the hot scissors. The patient is then placed in steep Trendelenburg to mobilize the abdominal contents cephalad. The initial approach differs based on patient gender, as care must be taken to preserve the vas deferens and uterine structures during mobilization. The ureters can typically be visualized through the thin peritoneum, which is incised posterior to the bladder to expose the ureter. The ureter is exposed by gently grasping the adventitia with a Maryland instrument, then tenting it anteriorly with the hook to bluntly dissect the ureter for 5 or 6 cm proximal to the ureterovesical junction (Fig. 89.5A). This dissection will ultimately allow the ureter to lie in the detrusor trough without tension. An 0 Prolene suture is placed through the suprapubic region as a hitch stich on the bladder. The needle is straightened and inserted under vision then passed through the bladder both medial and anterior to the apex of the trajectory of the detrusor trough. Tension is placed on the stitch to pull the bladder anteriorly toward the abdominal wall. This alignment facilitates detrusor dissection, particularly at the UVJ. Next, the detrusor layer is incised with hook electrocautery and the Maryland dissector, taking caution to avoid violation of the mucosal layer. Bladder filling to increase bladder pressure can facilitate this dissection. Dissection continues until the mucosa bulges throughout the incision for the length of the intended tunnel to the UVJ (Fig. 89.5B). The ureter is then sharply incised distal to the narrowed segment and the mucosa spatulated. The diseased segment is then excised until healthy ureter is encountered (Fig. 89.5C). The anastomosis is then approximated in a running fashion, taking care to leave the double-J stent in place. Once completed, the ureter is placed in the trough and the detrusor edges are approximated over the ureter with advancement stitches at the apex of the trough. Care is taken not to extend the trough too far or too tight, as iatrogenic obstruction must be avoided. The remaining detrusor defect is closed over the ureter with absorbable suture (5-0 polydioxanone or poliglecaprone) in an interrupted fashion (Fig. 89.5D). We recommend closing the fascia at all port sites due to hernia risk. A Foley catheter is left overnight as in the open approach and we typically leave a Jackson-Pratt (JP) drain. The ureteral stent is removed 2 months postoperatively.

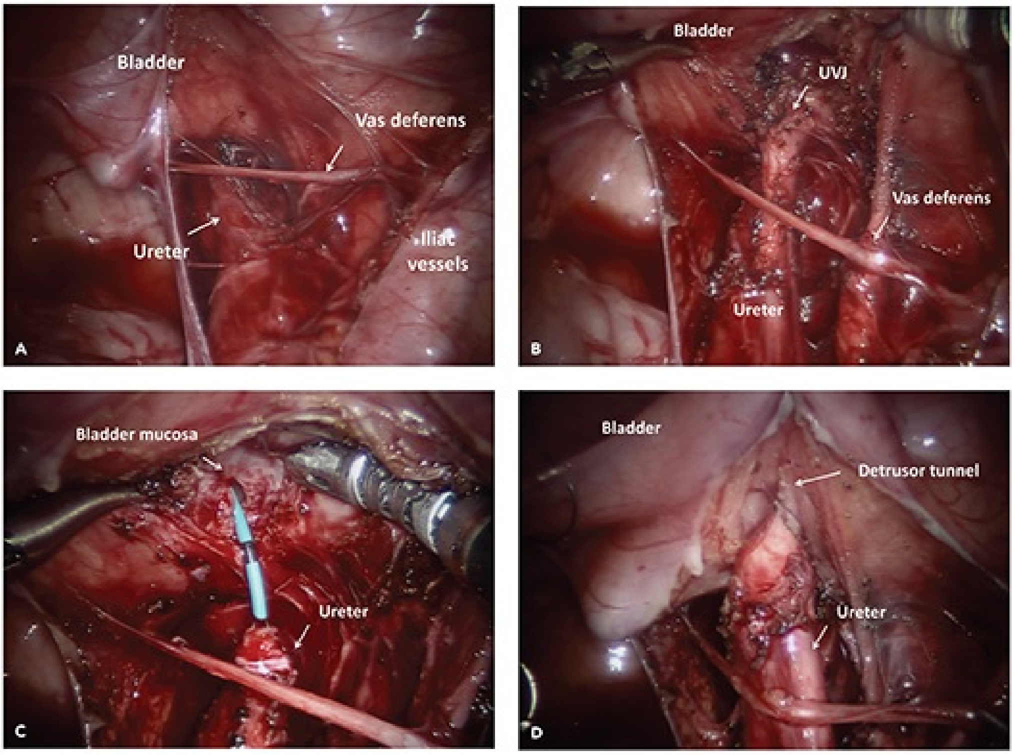

FIGURE 89.5 **A:** Peritoneum is incised over the iliac vessels and along the course of the ureter. In males, care is taken to mobilize the vas deferens so that it is not injured. In females, the peritoneum is incised anterior to the fallopian tube. **B:** The ureter is mobilized to the level of the UVJ and the narrowed diseased segment is visualized. The detrusor is incised, exposing the mucosa. Filling the bladder places tension on the muscle fiber and facilitates dissection. We prefer to use a Maryland and hook cautery via 5-mm ports. **C:** The ureter is incised distal to the diseased segment and the bladder mucosa is spatulated. The narrowed segment of ureter is excised and a running anastomosis is performed to the healthy ureter. **D:** Detrusorrhaphy is performed in an interrupted fashion to provide a gentle tunnel. The redundancy of the ureter is removed to improve drainage.

Staged Approach

Although repair of megaureters has been performed safely in newborns and young infants, there is a reasonable concern about reimplanting a markedly dilated ureter into the thin bladder wall of an infant (1,7). In some infants where severe dilation and diminished relative function (<35%) exists, end-cutaneous ureterostomy is a good alternative to reimplantation with tapering (7). The infant bladder often empties with high pressure, and postponing the definitive reimplantation while decompressing the obstructed ureter may reduce complications. In this case, one option is an end-cutaneous ureterostomy with resection of the distal stump. This provides reliable decompression of the kidney and usually improves the degree of ureteral dilation prior to reimplantation. In some cases, the ureterectasis recovers enough to avoid the need for tapering. This temporary measure will allow the reimplantation to be delayed until the infant is older and the bladder has grown. The takedown of the ureterostomy and ureteral reimplantation is usually done when the child is 12 to 18 months of age and can be performed intravesically or extravesically. If the initial function is poor and the kidney fails to recover following decompression, a nephrectomy rather than reimplantation may be preferred as the second procedure.

An alternative to the cutaneous ureterostomy that we use at CHOP is a refluxing ureteral reimplant. The ureter is mobilized and dismembered proximal to the narrowed segment. It is then reimplanted in a nontunneled fashion into the bladder. This has two functions: It preserves the continuity of the urinary tract and relieves the obstructive process and its sequelae to the kidney. We find this technique particularly useful in the infant bladder and have found that the great majority of these patients undergo a formal ureteral reimplant when age appropriate.

POSTOPERATIVE CARE

A catheter drainage is used for 24 to 48 hours. The externalized ureteral stent is left in place for 10 to 14 days. Children are discharged from the hospital on prophylactic antibiotics. Contrast injection of external stents at low pressure by gravity infusion with antibiotic coverage is performed to document drainage. If there is not prompt drainage around the stent, it is left for another 10 to 14 days and the stentogram is repeated. Internal stents are removed 4 to 6 weeks postoperatively. Patients are evaluated with a renal ultrasound 1 month after surgery or stent removal. If hydronephrosis is not improved, a renal scan should be obtained to rule out obstruction. A VCUG and renal scan should be performed 3 months after surgery, and the ultrasound is repeated at 1 year.

OUTCOMES

Complications

The most common complication related to surgery for megaureters is new or persistent reflux. This complication is more common when the surgery is performed for refluxing megaureters than for obstructed megaureters. Management options include observation with prophylaxis, endoscopic injection, or rarely, surgical revision. Obstruction is a rare complication, with reported rates of 0% to 4% (4,5,7). It should be initially evaluated endoscopically, as on occasion, a synechia has been reported to narrow the orifice. Strictures can be assessed by retrograde pyelography. Initial management with dilation and stenting may be successful, but failures will require formal surgical revision. Complications unique to endoscopic management include stent migration, stone formation, and stent colic, reported to occur in up to 31% of patients. Balloon dilation and/or laser incision can result in ureteral perforation, although these are rare occurrences in the literature. Because in most cases surgery is to relieve obstruction, patients with persistent vesicoureteral reflux do well and rarely need revision.

Results

Most series report success rates >90% (1,7–9). In a series of infants treated with reimplantation, 20% had reflux postoperatively; however, with time, a few patients had spontaneous resolution of their reflux, lowering the rate to 12.5% (10). Extravesical reimplants had rates of postoperative reflux similar to intravesical rates (12%). When performed bilaterally for megaureters, two-thirds of patients treated with extravesical reimplantation required intermittent catheterization for a period of 1 to 4 months (5). Success rates with endoscopic management are quite variable with rates (defined as no need for further intervention after stenting) ranging from 51% to 67%.

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CHAPTER 90 PRUNE BELLY (TRIAD) SYNDROME

DAVID B. JOSEPH

Triad syndrome—the clinical association of a thin flaccid abdominal wall, undescended testes, and bladder hypertrophy with hydroureters—was originally described in 1895 by Parker (1). Shortly thereafter, Osler (2) presented a similar constellation of findings in a child he described as having the appearance of “a wrinkled prune.” From that point, “prune belly” has unfortunately become synonymous with this syndrome. This clinical manifestation is also known as the Eagle–Barrett syndrome and the abdominal muscular deficiency syndrome. By classic description, the triad syndrome occurs in boys. However, 5% of patients are girls presenting with similar physical findings, with the obvious exception of the gonadal abnormality. The incidence of triad syndrome in the United States is approximately 1/26,000 live births of which 50% are white, 31% African American, and 10% Hispanic (3). Most cases are sporadic, although a familial occurrence has been described and might be influenced by the HNF1β gene (4,5).

Approximately three quarters of children with classic triad syndrome will have other associated anomalies. Urethral abnormalities, including atresia and megalourethra, have been reported but are not required as part of the triad. Urethral atresia is usually associated with a patent urachus. The most common skeletal abnormality is a thoracic deformity resulting in a protruded upper sternum, depressed lower sternum, and splayed ribs. Other less frequent skeletal deformities include talipes equinovarus, congenital hip dislocation, calcaneus valgus, polydactyly, syndactyly, arthrogryposis, scoliosis, and lordosis. Intestinal malformations are noted in approximately one-third of children and most often are due to defective fixation or malrotation of the midgut. Cardiac atrial or ventricular septal defects, patent ductus, and teratology of Fallot have been reported in approximately 15% of children (4). Oral manifestations that included enamel hypoplasia and jaw bone abnormalities have become recently appreciated and possibly due to chronic renal insufficiency (6). The perinatal mortality remains substantial most often due to prematurity and pulmonary complications (3).

DIAGNOSIS

The diagnosis of triad syndrome can be established in utero with fetal sonography. However, similar findings can be identified in a fetus with posterior urethral valves or the megacystis–megaureters syndrome. Close inspection for thinned, deficient, or absent abdominal wall musculature should hedge the differential diagnosis to that of the triad syndrome. In utero diagnosis allows for a planned neonatal investigation. Triad syndrome is typically obvious at birth with the pathognomonic physical findings of a loose, lax, wrinkled abdominal wall; flared chest; and undescended testes.

Several classifications of the triad syndrome have been established based on severity and initial clinical presentation. There is no single classification system that incorporates the total spectrum of this syndrome. For practical purposes, children can be grouped into severe, moderate, or mild presentations. With a severe presentation, survival is often limited by significant respiratory compromise due to pulmonary immaturity and dysplasia, as well as extensive renal dysplasia, resulting in a Potter-like syndrome. Children described with moderate involvement have combined renal and respiratory insufficiency, mandating close observation and early intervention to minimize the sequelae of pulmonary and renal compromise. The combination of increased bilateral renal echogenicity on sonography, chronic urinary tract infections (UTIs), and a nadir serum creatine of >0.7 mg per dL are prognostic for renal failure (7). Monitoring of the urinary system is necessary to prevent progressive renal deterioration due to stagnation of urinary flow, UTIs, and possible urinary tract obstruction. Urinary tract reconstruction may play an important role in limiting long-term morbidity. Children with mild involvement do not suffer from respiratory or renal compromise. While long-term follow-up is necessary, operative intervention is often limited to orchiopexy and abdominal wall reconstruction.

A team approach consisting of a pediatric urologist, neonatologist, nephrologist, pulmonologist, and cardiologist is required to maximize the outcome. The initial cardiorespiratory status of the neonate must be established. The baby should undergo a chest X-ray and, when indicated, cardiac sonography. Urologic evaluation commences with abdominal sonography and a baseline chemistry profile. Both the upper and lower urinary tract should be assessed. Attention should be placed on the degree of hydronephrosis, the volume of renal parenchyma, and its echogenicity. Often, there will be a disproportionate degree of distal ureteral dilation and megacystis compared to dilation of the proximal ureter and kidney. On occasion, a marked transition of ureteral dilation is noted. If the infant is clinically stable with normal renal function and is voiding per urethra or draining through a patent urachus, further diagnostic testing can be placed on hold.

Children with renal insufficiency require further imaging to differentiate renal dysplasia and stagnant urine flow from true obstruction. The MAG-3 renal scan has limitations in the newborn period but remains the most objective diagnostic tool. The voiding cystourethrogram can assess vesicoureteral reflux and the effectiveness of bladder emptying. The neonate with triad syndrome and hydroureteronephrosis is susceptible to bacteriuria and can quickly become symptomatic. Bacteriuria is often persistent and difficult to clear. Therefore, it is of utmost importance that any invasive lower urinary tract imaging be performed in a sterile environment, with the child receiving pre- and postprocedural antibiotics.

Megalourethra has been classified as scaphoid and fusiform (Fig. 90.1). The more common scaphoid defect is confined to the penile portion of the corpus spongiosum, resulting in a variable length of massively enlarged ventral, anterior urethra similar in appearance to a saccular diverticulum. The fusiform variety encompasses a defect of the corpus spongiosum and deficiency of one or both of the corpus cavernosum, resulting in circumferential ballooning of the urethra and generalized penile flaccidity. Megalourethra is usually an isolated defect but can present with upper urinary tract changes, including hydronephrosis, vesicoureteral reflux, and renal dysplasia. It has been reported to occur with the triad syndrome, which may represent a continuation of the abnormal mesodermal theory of development related to the triad syndrome.

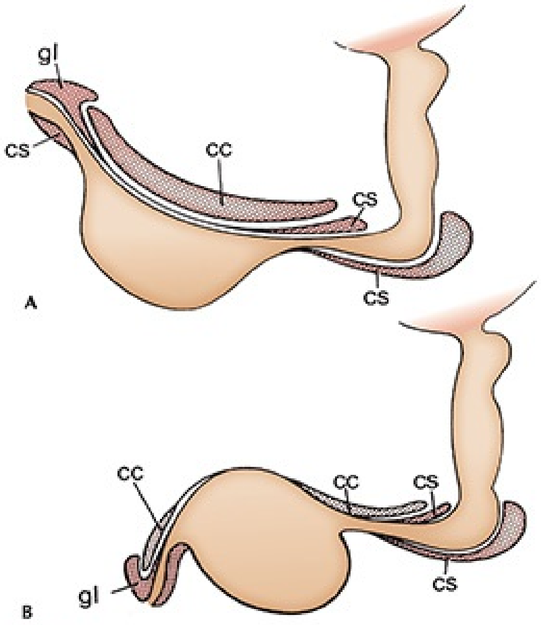

FIGURE 90.1 **A:** Scaphoid megalourethra. Corpora spongiosum (*CS*) is deficient throughout the ventral aspect of penile urethra. Corpora cavernosum (*CC*) is normal. **B:** Fusiform megalourethra. Both corpora spongiosum and cavernosum are deficient. Glans (*gl*) is normal in both variants.

INDICATIONS FOR SURGERY

Each child presents with a unique constellation of problems resulting in its own set of considerations and requires individualized care (8). Therefore, no one treatment plan is appropriate for all children. In general, operative management can be divided into three broad areas: reconstruction of the urinary system, reconstruction of the abdominal wall, and transfer of the intra-abdominal testes to the scrotum.

Urinary Tract Reconstruction

Controversy surrounds the need for aggressive urinary tract reconstruction. Early aggressive operative intervention for all children is countered by the fact that renal dysplasia may be inherent, thus preventing any intervention from improving the functional status. In addition, imaging studies depicting significant hydroureteronephrosis do not always correlate with obstruction or the potential for symptoms, and hydroureteronephrosis by itself does not mandate reconstruction. Urinary tract reconstruction is beneficial in a child who has a component of obstructive uropathy and has been shown to have improved renal function with decompression of the urinary system. Reconstruction is also of benefit in the child who has progressive hydroureteronephrosis associated with increasing renal compromise and in the child who has recurrent symptomatic UTIs due to stagnant urine flow.

Urinary diversion plays an initial temporary role in the management of acute renal failure or sepsis. Often, children with urethral atresia or obstruction will present with a patent urachus, effectively emptying their lower tract. Infants with associated posterior urethral abnormalities resulting in obstruction or poor bladder decompression, who are not candidates for intermittent catheterization, benefit from a vesicostomy. A vesicostomy, however, may not adequately drain the upper urinary tract due to a relative obstruction of the ureter at the level of the bladder or poor urinary transport secondary to a highly compliant, adynamic ureter. Vesicostomy should be undertaken only when bladder catheterization has been shown to provide effective decompression of the upper urinary tract. Otherwise, temporary diversion of the upper urinary tract will be required.

Nephrostomy tube drainage is helpful to stabilize an acute problem but long-term effectiveness is limited, resulting in a need for a more formal upper urinary tract diversion. There is a theoretical advantage in performing upper tract diversion as proximal as possible. This should maximally relieve stress to the kidney and limit stagnation of urine in a dilated tortuous ureter. However, there is often a disproportionate degree of distal versus proximal ureteral dilation that can prevent easy access of the proximal ureter.

It is compelling to perform a reduction cystoplasty during urinary reconstruction in a child with triad syndrome. However, long-term follow-up has been mixed regarding identifiable objective advantages (9–11). With time, the bladder will often regain its large size and lose its tone, resulting in inadequate emptying. For these reasons, it is not practical to proceed with reductive cystoplasty as the primary indication for urinary reconstruction. If a large, poorly contracting bladder results in inadequate urinary emptying, intermittent catheterization would be a more appropriate form of initial management. However, when undertaking formal urinary reconstruction with upper tract ureteral tailoring, reductive cystoplasty is practical and may provide limited improved bladder emptying (11).

Reconstruction of the Abdominal Wall

Several techniques have been devised to maximize the cosmetic benefits of abdominal wall reconstruction in children with triad syndrome. There is evidence indicating that the muscular defect is more pronounced centrally and caudally. Initial reconstructive efforts were based on removal of this abnormal tissue. While the appearance of the abdomen was improved, it was not ideal and resulted in a transverse incision and loss of the umbilicus. Monfort described preservation of the umbilicus, and others have added various modifications (12–17). Based on these approaches, abdominal wall reconstruction now allows for an excellent cosmetic and functional outcome (15–18). The benefit of abdominal wall reconstruction is dependent on the degree of abdominal wall laxity. The timing for this procedure should be based on the need for other operative intervention. If it is obvious that the child will not require upper urinary tract reconstruction, abdominal wall reconstruction can be undertaken at any time. If, however, there is the potential for upper urinary tract reconstruction, abdominal wall reconstruction should be deferred until the time of that intervention.

Orchiopexy

The timing for orchiopexy can be individualized based on the child’s need for urinary reconstructive surgery. If urinary reconstructive surgery is required, orchiopexy can be performed at the same time. If urinary reconstructive surgery is not required, then the timing and approach are variable. Placement of the testes within the scrotum is important for maintaining hormone function, allowing for pubertal development and sexuality, but unfortunately fertility is not improved (19). Biopsies of testes have shown limited sperm production, atypical germ cells and features consistent with Sertoli-cell-only, Leydig cell hyperplasia significantly limiting future fertility, and raising concern for malignant potential (20–22). Recently, case reports indicate that intracytoplasmic sperm injection may be feasible (23,24).

Urethral Reconstruction

Correction of the megalourethra is dependent on presenting symptoms of urinary dribbling and/or urinary infections. Most often, operative correction is undertaken because of the unusual appearance of the megalourethra. Urethral tapering is an appropriate treatment.

ALTERNATIVE THERAPY

Alternative therapy relates to conservative medical management and observation. The floppy abdominal wall and poor musculature can be supported with use of an elastic corset.

SURGICAL TECHNIQUE

Vesicostomy

A vesicostomy is placed between the symphysis and umbilicus. A 2- to 3-cm incision is made down to the rectus fascia. A triangular segment of fascia is removed, which will help limit problems of stenosis. The rectus is separated, the space of Retzius is entered, and the dome of the bladder is identified along with the urachus and umbilical ligaments. The bladder is opened in this region to decrease the risk of prolapse. The bladder wall is secured to the rectus fascia with 4-0 polyglactin sutures, and the bladder epithelium is approximated to the skin with 4-0 chromic gut.

Distal Cutaneous Ureterostomy

When there is minimal proximal dilation, a low distal cutaneous ureterostomy provides adequate decompression with relief of stagnated urine flow and stabilization of renal function. The ureter can be approached from a small (2.5-cm) incision placed in a low inguinal location. The muscles are split to enter the retroperitoneum. The ureter may have the appearance of bowel due to its large size. When in doubt, a 21-gauge needle should be passed, aspirating contents to confirm urine. Once confirmed, the ureter is opened at the level of the medial umbilical ligament (obliterated umbilical artery). The size of the ureter usually prevents postoperative stenosis, allowing for either an end or loop ureterostomy. An advantage of distal diversion is noted at the time of definitive urinary reconstruction: the proximal urinary system will have remained uncompromised, allowing for easier mobilization and greater flexibility when tailoring the ureter.

Ureteral Reconstruction

When definitive primary urinary reconstruction is necessary, the initial approach to the ureter can be extravesical. The ureter is isolated at the level of the bladder and proximal dissection ensues. If there is an obvious transitional phase noted on imaging between the dilated distal ureter and the normal proximal ureter, the dissection should be continued proximal to the transition point. During dissection, the adventitial tissue surrounding the ureter is preserved to prevent devascularization. All of the distal ureter is excised when there is adequate length for the proximal ureter to be tapered if needed and reimplanted in the bladder in a standard fashion or with the assistance of a psoas hitch.

If total proximal and distal ureteral tailoring is necessary due to massive dilation, full mobilization of the ureter will be required. This can be accomplished via a retroperitoneal approach, but in most children, it is helpful to enter the peritoneum and reflect either the descending or ascending colon along the white line of Toldt. The dilated ureter is often exceedingly redundant and tortuous. Straightening of the ureter without devascularization is required. The functional capability of the ureter for peristalsis and transmission of urine into the bladder parallels the degree of hydroureter. Therefore, ureteral tapering may enhance urinary flow into the bladder. Multiple techniques exist for ureteral tailoring, including ureteral imbrication and formal ureteral excision as with any megaureter (Fig. 90.2). Ureteral imbrication is appropriate for marginally dilated ureters. But, when massive ureteral dilation is present, which is usually the reason for reconstruction, formal excision is preferred, eliminating the bulky tissue that results from the large imbricated ureter.

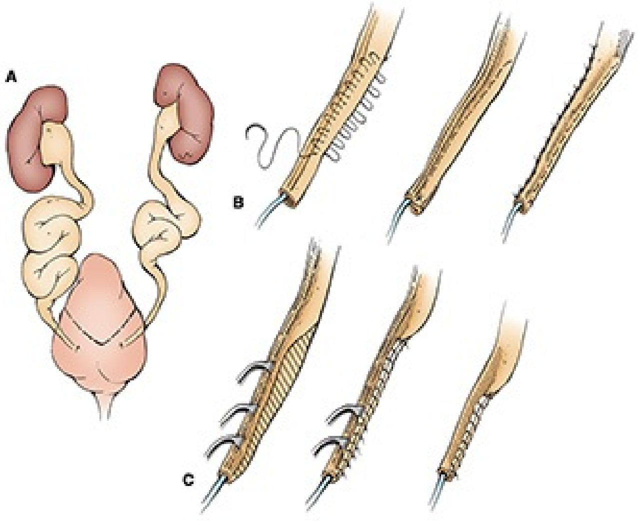

FIGURE 90.2 **A:** The tortuous dilated ureter is carefully straightened without compromising blood supply. The redundant portion is excised and the remaining distal segment tapered if necessary. **B:** Ureteral folding over a 10Fr or 12Fr ureteral catheter. **C:** Formal ureteral tapering with excision and closure. *Note:* The continuous running closure stops 1 to 2 cm from the end of the segment, followed by interrupted suture placement, allowing for excision of the distal end of the ureter without compromising the running closure.

The ureter is tapered loosely over either a 10Fr or 12Fr catheter, depending on the child's age and size. The excised ureteral segment may need to take an unconventional course to preserve adequate blood supply to the tailored ureter. If a large, redundant renal pelvis is present in association with a dilated proximal ureter, a reduction pyeloplasty should be performed in line with the ureteral excision. Preservation of the proximal ureteral blood supply is essential.

After excision, the ureter and renal pelvis are closed in a two-layer technique using absorbable sutures. The first running suture line is 5-0 or 6-0 chromic gut, polydioxanone, or polyglactic acid, directly apposing the mucosa and muscularis of the ureter. The second layer reapproximates the adventitial tissue using the same suture material. Both running layers are discontinued a few centimeters from the distal end of the ureter. The very distal portion of the ureter is closed with interrupted sutures. This allows for excision of the distal ureter without interruption of the running suture line. Enough ureteral length should be preserved to allow for a tunneled antirefluxing ureteroneocystostomy in all cases. A ureteral stent will remain for 5 to 10 days postoperatively.

Reduction Cystoplasty

Reductive cystoplasty should include the urachus and the majority of the dome of the bladder (Fig. 90.3). A 2- to 3-cm strip of mucosa is removed from one side of the bladder wall, allowing for a reinforced overlapping suture line. The bladder is closed in three independent layers using a running suture of 3-0 chromic gut, polydioxanone, or polyglactic acid. A suprapubic tube is inserted for postoperative monitoring regarding the effectiveness of bladder emptying.

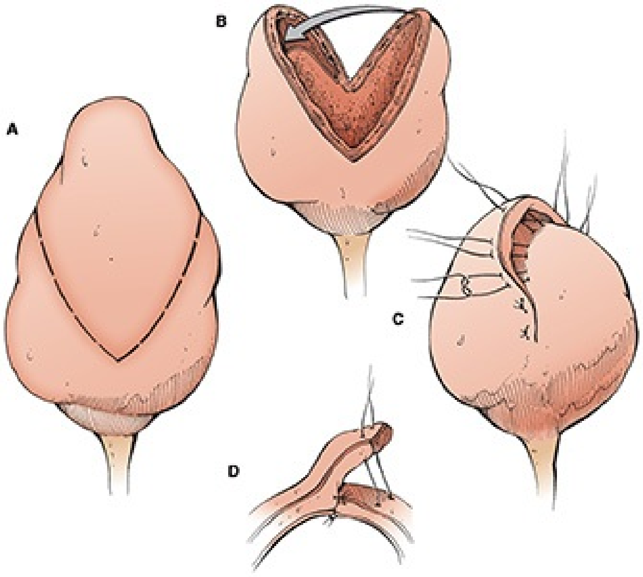

FIGURE 90.3 Reduction cystoplasty. **A:** The dome of the bladder, including any urachal remnant, is removed. **B:** A 2- to 3-cm mucosal strip is then removed from one portion of the bladder. *Arrow* indicates "vest over pants" closure. **C** and **D:** The bladder is closed with overlapping suture lines.

Abdominal Wall Reconstruction

The Monfort approach begins with a midline incision from the tip of the xiphoid process carried inferiorly, circumscribing the umbilicus, leaving an adequate umbilical island of tissue, and ending at the symphysis pubis (Fig. 90.4). A full-thickness skin flap is created bilaterally, elevating the subcutaneous fat from the underlying fascia. The dissection is continued laterally to the anterior axillary line. Often, there will be variability and asymmetry of muscular development. Care must be taken not to enter the peritoneum while mobilizing the skin flaps, in particular, in areas where the fascia is relatively thin. An incision is then made lateral to the superior epigastric artery through the fascia, entering the peritoneum. The incision is continued lateral and parallel to the course of the superior and inferior epigastric arteries from the costal margin to the symphysis pubis. The fascia is then elevated and the contralateral superior and inferior epigastric arteries are identified. A second parallel incision is made lateral to these arteries. The central fascial bridge with the umbilical island is now supported by both sets of epigastric arteries. The two lateral incisions provide excellent exposure for orchiopexy and major urinary tract reconstruction when required. A variation of this exposure has been described using only one incision through the side of greater laxity in an attempt to improve strength and abdominal wall function (15).

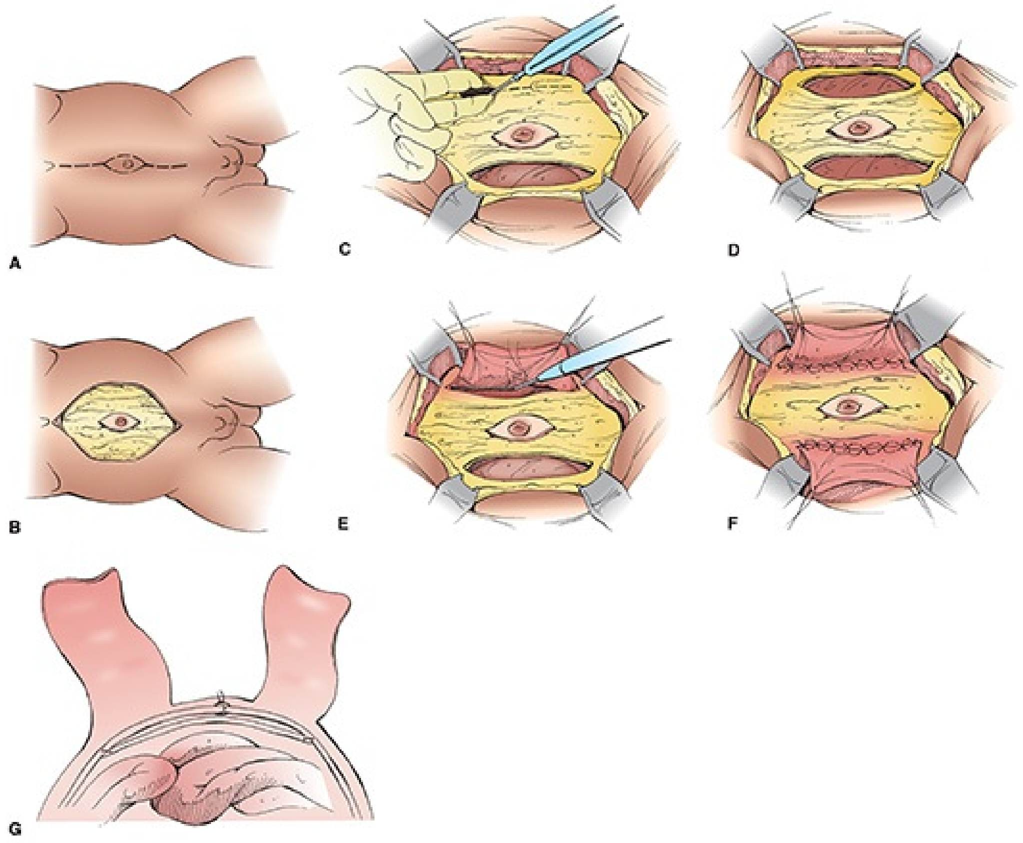

FIGURE 90.4 **A:** An incision is begun at the xiphoid, circumscribing the umbilicus, and carried down to the pubis. **B:** Skin flaps are then elevated, dissecting between the subcutaneous fat and the fascial layer. The lateral extension is the anterior auxiliary line. **C and D:** The umbilicus is supported by the central fascial bridge. Incisions will be made into the peritoneum lateral to the epigastric vessels. The central fascial bridge is easily manipulated to allow for excellent intra-abdominal exposure. **E:** At the time of closure, a line is scored on the peritoneal surface of the fascia. **F:** The central fascial strip is then secured laterally to the scored fascia line with a running suture of 2-0 or 3-0 polyglactin. **G:** The lateral fascia is then secured in the midline above and below the umbilicus with 2-0 or 3-0 polyglactin. Centrally, the fascia is secured directly to the umbilicus. This allows for an overlapping reinforced fascial wall closure. Subcutaneous tissue is closed with 3-0 or 4-0 plain gut and the skin with a running subcuticular 4-0 or 5-0 polyglactin suture.

At the time of abdominal closure, the lateral fascia wall is secured to the central fascial strip with a running 2-0 or 3-0 polyglactin suture. The lateral fascia can be scored with the cautery along the intended suture line to enhance adherence. The edge of the lateral fascia is then overlapped and secured in the midline with figure-of-eight suture placement using 2-0 or 3-0 polyglactin sutures. This pants-over-vest closure provides additional ventral support. When severe laxity is present, additional abdominal support can be achieved with mobilization and transposition of bilateral rectus femoris muscles (17). Two flat 7Fr suction drains are placed between the fascia and the subcutaneous space. The skin flaps are then tailored, removing the excess dermis, allowing for a midline and periumbilical closure. The skin flap is closed in multiple layers, securing the subcutaneous tissue with 4-0 plain gut sutures. The epithelial edge is reapproximated with a running subcuticular suture of 4-0 or 5-0 polyglactin. The drains remain in place for 2 or 3 days for decompression of the dead space. An alternative laparoscopic-assisted approach may allow for improved abdominal wall plication and simultaneous orchiopexy (25).

Orchiopexy

The testicle is usually found closely associated with a dilated distal ureter and should be released from the ureter in order to determine whether it can be delivered into the scrotum without sacrifice of the gonadal artery. If orchiopexy is undertaken early, particularly within the first 6 months of life, there is often adequate vascular length to deliver the testicle directly into the scrotum without transection of the gonadal artery (8). After the testicle is separated from the ureter, an incision is made in the peritoneum lateral to the gonadal artery and directed to the internal ring. A second incision medial to the gonadal vessels is made in the peritoneum and continued caudally along the course of the vessels and vas deferens. It is important not to disrupt the vascular supply of the peritoneal pedicle running on both sides of the vas deferens. If it becomes apparent that the testes will not reach into the scrotum after mobilization, the gonadal artery is sacrificed to obtain adequate length for the testicle to be delivered in the scrotum, as described by Fowler and Stephens (26). The blood supply to the testes is maintained by the vasal artery and small anastomotic channels within the peritoneal flap. A tunnel is then made into the scrotum and an incision placed inferiorly in the scrotum to create a dartos pouch. A clamp is passed from the scrotum to the inguinal canal. The testicle is grasped, pulled down through the tunnel, and delivered to the scrotum. Care must be taken not to twist or place the peritoneal pedicle on tension. If desired, the tunica vaginalis overlying the testicle can be secured to the dartos tissue with a 5-0 polydioxanone suture to reduce tension. When the orchiopexy is approached as an independent procedure, it can be undertaken laparoscopically either in a single or staged fashion (27).

Urethral Reconstruction

Urethral reconfiguration is most effective by formal excisional tapering, as described by Nesbitt (Fig. 90.5). An incision is made in line with the previous circumcision or beneath the coronal sulcus if the patient is uncircumcised. The penile shaft skin is then mobilized to the base of the penis. The anterior urethral wall is usually thin and poorly supported, and care needs to be taken to prevent inadvertent entrance into the urethra. The urethra is split in the midline ventrally. The redundant portion of the urethra is excised, and the urethra is reapproximated over a 10Fr or 12Fr catheter, depending on the child’s age. The urethra is closed in two layers using 6-0 or 7-0 polydioxanone or polyglactic acid sutures. The glanular urethra is usually patent, and the reconstruction is limited to the penile shaft. Because of poor development of the spongiosum, it may be difficult to achieve additional tissue for a second layer of coverage. The penile shaft skin is then secured to the coronal tissue with 6-0 chromic sutures. A urethral stent or catheter is placed for 7 days. The penis is dressed with the personal technique used for a hypospadias repair.

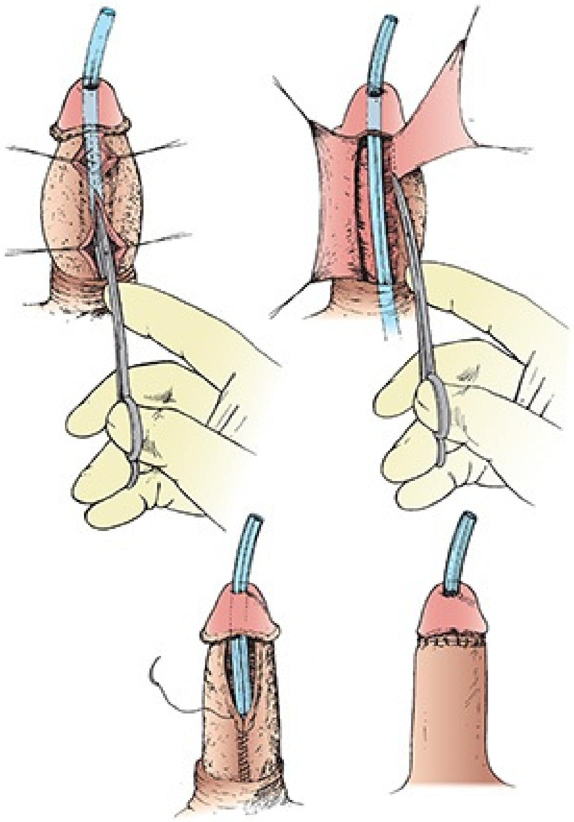

FIGURE 90.5 Nesbitt reduction urethroplasty for megalourethra. **A:** The urethra is opened vertically in the midline, followed by excision of the lateral redundant tissue (B). **C:** Reconstruction is carried out over a 12Fr catheter using two layers of running suture. **D:** The penile skin is reapproximated to the coronal margin circumferentially.

A variant of megalourethra is the “megameatus with an intact prepuce” (MIP). This is corrected using standard hypospadias techniques (Fig. 90.6). The glans is infiltrated with a mixture of 1:200,000 epinephrine for hemostasis. Parallel incisions are made lateral to the urethral plate and extended into the glans, creating two glanular wings. The incisions are continued along the shaft of the penis and connected beneath the urethral meatus. The urethra is then tubularized over an 8Fr, 10Fr, or 12Fr catheter using 6-0 or 7-0 polyglactic or polyglycolic acid sutures. The glans is closed in the midline, reapproximating the deep tissue with 6-0 Vicryl and the epithelium with 6-0 chromic. The penile shaft skin is brought up and the excess excised and then reapproximated to the coronal ring. A urethral stent or catheter can be positioned for 7 days, depending on the length of the defect. The penis is dressed as discussed earlier.

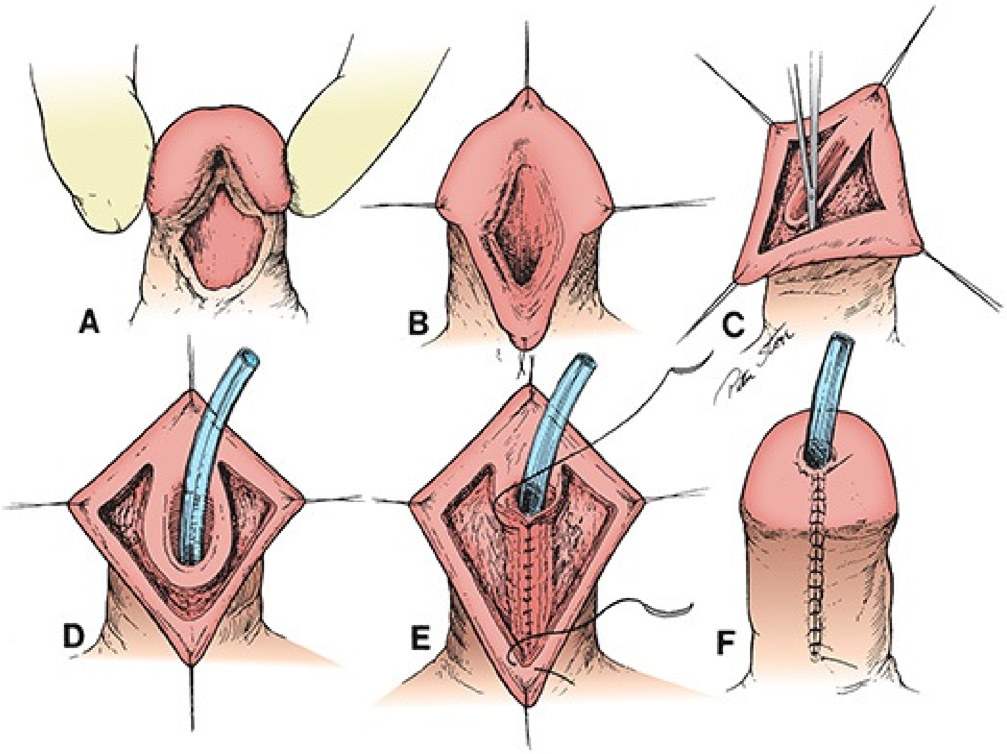

FIGURE 90.6 **A:** Pyramid procedure for repair of the megameatus with intact prepuce variant of hypospadias. **B and C:** Stay sutures are placed and the urethra is mobilized sharply. **D and E:** The urethra is tubularized in a two-layer technique. **F:** Subcutaneous glandular tissue is reapproximated and the skin closed.

OUTCOME

Complications

Ureteral devascularization resulting in ischemia and subsequent obstruction can occur if attention has not been paid to the ureteral blood supply. As with any ureteral reimplantation, vesicoureteral reflux and ureteral obstruction are rare but possible events. The risk of bowel obstruction is present as in any intra-abdominal procedure. Testicular ischemia and atrophy due to a single-stage Fowler–Stephens procedure has been reported to occur in 30% of children. This can be decreased with a staged approach (19,27). More importantly, ischemia may be prevented with early orchiopexy, eliminating the need for sacrificing the gonadal vessels.

The cosmetic appearance following urethral tapering is good and limited only by any residual corpora cavernosa deficiency. Postvoid dribbling can be abolished, and the risk of urinary infections due to stagnant urine can be diminished. The most common complication is that of a urethral fistula due to limited spongiosum tissue for a multiple-layer closure. The circumferential degloving of the penis with subsequent reapproximation of the penile shaft skin to the corona will limit fistula formation. The greatest risk for a fistula is located at the level of the ventral coronal sulcus.

Results

The results of urologic reconstruction can be very gratifying in the initial postoperative period, in particular, the cosmetic appearance of the abdomen and the improvement in upper urinary tract drainage. Voiding function may become more effective due to the benefits of abdominal wall reconstruction and reduction cystoplasty (17,18). However, with time, there can be an increase in both bladder size and ureteral dilation. This is often due to ineffective voiding and is independent of bladder reduction. For those reasons, long-term follow-up of the urinary tract is required. Patients should be prepared for the potential need for intermittent catheterization. Because of normal sensation, children are often unwilling to cooperate with urethral catheterization. Placement of an appendicovesicostomy should be considered if catheterization appears to be a realistic possibility at the time of urinary reconstruction. An appendicovesicostomy provides excellent access to the bladder in a normally sensate child.

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CHAPTER 91 CHILDHOOD RHABDOMYOSARCOMA

FRANK J. PENNA AND MARTIN A. KOYLE

Rhabdomyosarcoma (RMS) is the most common soft tissue sarcoma of childhood, accounting for 5% of all cancers in children and about half of all soft tissue sarcomas. RMS is also the most common extracranial neoplasm, following neuroblastoma and Wilms tumor. This tumor is nonencapsulated, grows rapidly, spreads locally to regional lymph nodes, but can also metastasize hematogenously and is not limited to skeletal muscle. In children and adolescents (<20 years of age), the incidence is 4.3 cases per million, with approximately 350 new cases diagnosed annually in the United States (1). Genitourinary RMS, involving the bladder, prostate, paratestis, vagina, and uterus represents 18% to 20% of all cases (1). There is a bimodal age distribution with a peak incidence in the first 2 years of life and again during early adolescence (2).

RMS was first described in 1850 by Wiener (3). Little was published on RMS, until the 1950s when a histologic classification system for the condition was described. Theriault initially described alveolar RMS in children and Stout described pleomorphic RMS (4,5). In 1958, Horn and Enterline created the classification of RMS that reflected varying degrees of embryonic rhabdomyogenesis (6). In fact, RMS is considered one of the “small round blue cell tumors of childhood,” the others being neuroblastoma, Ewing sarcoma, and lymphoma. Once almost uniformly fatal, RMS has become highly curable with multimodal therapy, with the majority of patients achieving long-term survival. These advances were the result of the Intergroup Rhabdomyosarcoma Study Group in exploration of the optimal therapy for childhood RMS.

The Intergroup Rhabdomyosarcoma Study Group (IRSG) initiated studies in the United States in 1972 to achieve better survival with less morbidity in successive coordinated large, multicenter trials. During the first IRSG study (IRSG I) from 1972 to 1978, radical surgical resection was employed with adjuvant chemotherapy, traditionally using vincristine, dactinomycin, and cyclophosphamide (VAC) at the expense of bladder preservation, with a rate of preservation of only 23% at 3 years (3). The second IRSG study from 1979 to 1984 incorporated neoadjuvant chemotherapy and/or radiation prior to surgical excision. In this study, overall survival remained high at 80% with 10% of patients achieving relapse-free survival with chemotherapy alone (3). Early in these studies, when the bladder was involved with tumor, radical exenterative surgery was employed. With the success of chemotherapy, bladder-sparing surgery was then invoked; however, only 25% being left with an intact, functional bladder (3).

The third IRSG from 1985 to 1992 marked the advent of the organ-sparing era. With bladder-sparing surgery, retained bladder function of 60% was noted at 4 years after diagnosis while preserving an 83% survival rate (3). Also during this time, chemotherapy was standardized to include doxorubicin, cisplatin, and etoposide in patients with bladder and prostate RMS. IRSG IV initiated the use of the tumor–node–metastasis (TNM) pretreatment staging system and also concluded that hyperfractionated radiation was not more beneficial compared to standard conformal radiation therapy.

The IRSG is now the Soft Tissue Sarcoma Committee of the Children’s Oncology Group, which has taken over responsibilities for these trials, and is currently investigating new chemotherapeutic options including sorafenib, pazopanib, crizotinib, TH-302, aurora-kinase inhibitors, and anaplastic lymphoma kinase inhibitors (7). Patient survival, which was only 40% to 73% prior to chemotherapy, has improved to 86% in IRSG IV with VAC (8).

PATHOLOGIC FEATURES AND MOLECULAR MECHANISMS

RMS is derived from immature striated skeletal muscle cells in various stages of embryonic myogenesis. There are three variants of RMS as described by the IRSG: embryonal, alveolar, and pleomorphic RMS. Embryonal RMS, the most common subtype, is typically found in infants and young children and includes sarcoma botryoides, a polypoid variant that is found in the hollow organs such as the bladder or vagina and carries a favorable prognosis as well as the spindle cell variant which is common in the paratesticular region and also carries a favorable prognosis (1). Embryonal RMS resembles fetal striated muscle at 7 to 10 weeks gestational age and is composed mainly of spindle-shaped cells with a central nucleus that stains for nuclear transcription factors such as myogenin or MyoD1, surrounded by eosinophilic cytoplasm (3). Embryonal RMS is associated with an 11p15.1 loss of heterozygosity and, in general, carries a favorable prognosis (9).

Alternatively, alveolar RMS is the second most common form and portends a poorer prognosis; it resembles striated muscle at 10 to 21 weeks gestational age, has a vague resemblance to fetal alveoli, with clusters of small round cells adherent to fibrosepta, and is typically diagnosed in older children (1,6). Alveolar RMS also has distinct genetic mutations, including t(2;13) or t(1;13) translocation, which generate the PAX3-FKHR and the PAX7-FKHR gene fusions, respectively. The presence of these gene fusions have been associated with a high rate of relapse and death in patients with metastatic disease, particularly patients who exhibit the PAX3-FKHR mutation, which is present in approximately 70% of alveolar RMS (3). The downstream effect of these mutations results in decreased gene products that play a role in normal myogenic differentiation. These mutations, and not the histologic features, have been implicated as the source of the poorer outcome in this subtype (6). In fact, fusion-negative alveolar RMS behaves more characteristically of embryonal in terms of presentation and clinical outcome.

Pleomorphic is not classically associated with childhood RMS originating from the prostate or bladder (1). Undifferentiated type RMS is remarkably anaplastic and difficult to identify due to nonspecific large round cells with scant cytoplasm and lack of antigenic markers.

RMS is associated with particular familial conditions that result in a genetic predisposition to developing the condition including Li-Fraumeni, Beckwith-Wiedemann, Gorlin syndrome, and neurofibromatosis type 1, with the latter seen commonly with genitourinary RMS with embryonal histology (1). The most common genetic mutations include PAX-FKHR gene fusions, alterations affecting MyoD1 and myogenin expression, as well as the retinoblastoma and p53 pathways (3). There has been much effort put forth on applying the recent advances in molecular biology and bioinformatics to provide more robust criteria for risk stratification, predicting clinical outcome, and tailoring “rational” therapy based on the identification of critical targets in RMS (10).

DIAGNOSTIC EVALUATION AND STAGING

Signs and symptoms are dictated by the primary organ(s) involved. Hence, imaging will vary accordingly. Evaluation of pelvic organs with diagnostic imaging modalities including conventional radiography, ultrasonography, computerized tomography (CT), magnetic resonance imaging (MRI), and nuclear medicine studies such as bone scan, positron emission tomography (PET). MRI has been shown to improve the detection of residual pelvic RMS with well-delineated tissue planes and more accurate assessment of tumor invasion into adjacent structures compared with CT (11). Suspected paratesticular RMS are evaluated initially with scrotal ultrasound. Metastatic workup is completed with a chest X-ray, liver function tests, bone scan, and bone marrow biopsy. The initial staging algorithm is demonstrated in Figure 91.1.

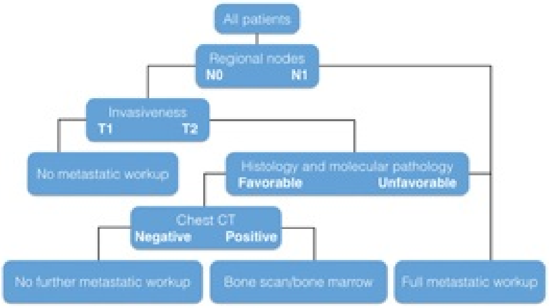

FIGURE 91.1 RMS initial staging algorithm. *CT*, computerized tomography. (Adapted from Weiss AR, Lyden ER, Anderson JR, et al. Histologic and clinical characteristics can guide staging evaluations for children and adolescents with rhabdomyosarcoma: a report from the Children's Oncology Group Soft Tissue Sarcoma Committee. *J Clin Oncol*. 2013;31[26]:3226–3232.)

The mechanism of metastasis for RMS is variable, with local and regional spread via lymphatic channels present in approximately 20% of patients (3). The most common sites of hematogenous metastases include lung, bone marrow, and bone, whereas sites such as the liver or brain are rare. Prognostic factors that are considered unfavorable include primary sites such as bladder or prostate, the presence of distant metastasis at diagnosis, regional lymphadenopathy, primary tumors greater than 5 cm, and age younger than 1 year or older than 10 years (2). A substantial number of patients with low-stage disease are subjected to unavoidable testing so there has been an effort to characterize patients with low-stage, node-negative, and noninvasive RMS disease early to avoid studies such as bone marrow aspirate and bone scan as well as the unnecessary radiation exposure from chest CT (12). The IRSG protocols included both preoperative staging and postoperative grouping (8) (Tables 91.1 and 91.2). The IRSG I to III studies grouped patients based on completeness of resection, introducing biases (shifting patients from group 1 to group 3) that are not seen with the use of the TNM system in IRSG IV and V.

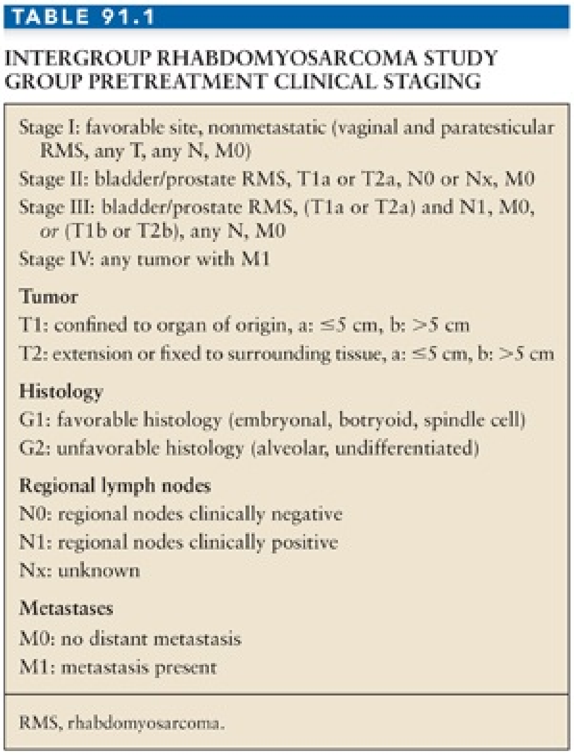

TABLE 91.1

INTERGROUP RHABDOMYOSARCOMA STUDY GROUP PRETREATMENT CLINICAL STAGING

Stage I: favorable site, nonmetastatic (vaginal and paratesticular RMS, any T, any N, M0)
Stage II: bladder/prostate RMS, T1a or T2a, N0 or Nx, M0
Stage III: bladder/prostate RMS, (T1a or T2a) and N1, M0, *or* (T1b or T2b), any N, M0
Stage IV: any tumor with M1

Tumor
T1: confined to organ of origin, a: ≤5 cm, b: >5 cm
T2: extension or fixed to surrounding tissue, a: ≤5 cm, b: >5 cm

Histology
G1: favorable histology (embryonal, botryoid, spindle cell)
G2: unfavorable histology (alveolar, undifferentiated)

Regional lymph nodes
N0: regional nodes clinically negative
N1: regional nodes clinically positive
Nx: unknown

Metastases
M0: no distant metastasis
M1: metastasis present

RMS, rhabdomyosarcoma.

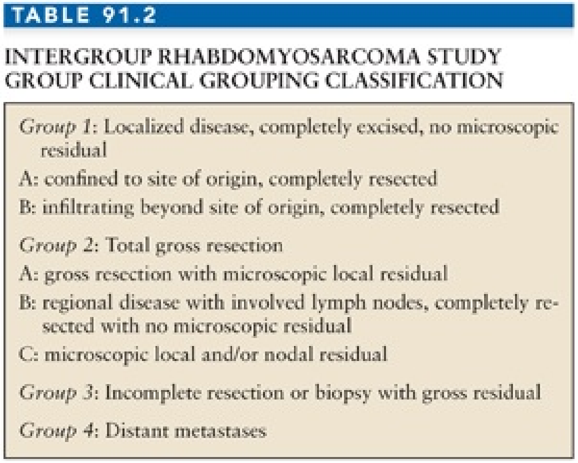

TABLE 91.2

INTERGROUP RHABDOMYOSARCOMA STUDY GROUP CLINICAL GROUPING CLASSIFICATION

Group 1: Localized disease, completely excised, no microscopic residual
A: confined to site of origin, completely resected
B: infiltrating beyond site of origin, completely resected

Group 2: Total gross resection
A: gross resection with microscopic local residual
B: regional disease with involved lymph nodes, completely resected with no microscopic residual
C: microscopic local and/or nodal residual

Group 3: Incomplete resection or biopsy with gross residual

Group 4: Distant metastases

Bladder and Prostate Rhabdomyosarcoma

Bladder and prostate RMS present initially with obstructive urinary symptoms, including urinary frequency, stranguria, hematuria, incontinence, and acute urinary retention, and tend to be located at the trigone and bladder neck. Bladder RMS typically grows intraluminally and usually occurs in the botryoid form. Most present by 10 years of age, whereas neonatal RMS is very rare but has been reported in the literature and detected via prenatal ultrasonography (13).

Prostatic RMS usually presents as a solid mass and carries a poorer prognosis (2). On physical examination, an abdominal mass may be present. Imaging including ultrasonography, CT, or MRI can delineate disease extent including retroperitoneal lymphadenopathy, and cystoscopy can facilitate diagnosis via transurethral biopsy with a pediatric resectoscope or cold-cup biopsy forceps (Fig. 91.2).

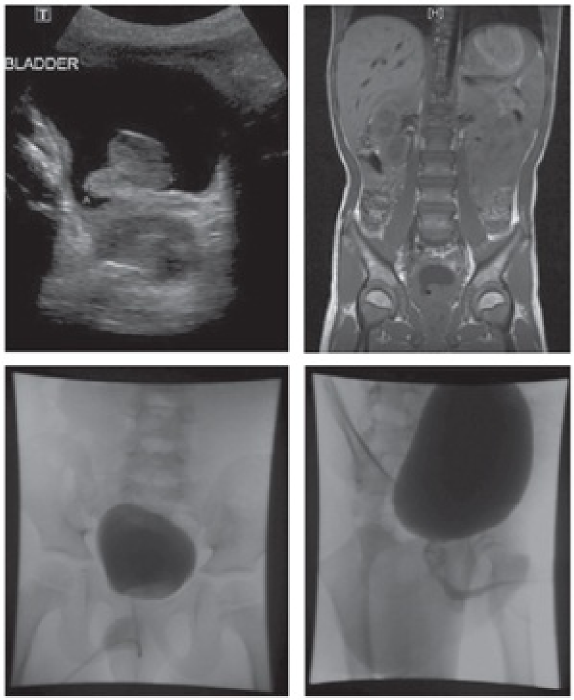

FIGURE 91.2 A 2-year-old boy with RMS demonstrated by ultrasound (**top left**) of the bladder showing mass filling bladder lumen and coronal MRI (**top right**), T1-weighted. voiding cystourethrogram (**bottom left**) showing filling defect in the bladder and ball valving of mass in posterior urethra (**bottom right**).

A study from the late 1980s of 36 children with RMS employed a multimodal approach including conservative surgery when indicated, radiation, and chemotherapy with VAC, with an overall and event-free survival rate of 80% and 74%, respectively (14). The study also emphasizes the importance of urethral biopsies when evaluating bladder and prostate RMS because urethral involvement can be subtle due to submucosal extension and may not be apparent with cystoscopy alone.

Serial imaging with CT or MRI can be used to assess response to treatment, including chemotherapy. Chest CT is useful for evaluating lung metastases, and more recently, PET has been implemented, but its use is still under investigation (3). Based on the tumor site, grade, presence of lymphadenopathy, and metastatic lesions, patients are categorized into low-, intermediate-, or high-risk groups.

Paratesticular Rhabdomyosarcoma

Paratesticular RMS presents as a unilateral painless scrotal mass or with scrotal swelling that is appreciably distinct from the testis. Paratesticular RMS represents 7% to 10% of genitourinary RMS with a peak presentation of 1 to 5 years of age (2). The majority of paratesticular tumors are stage 1 and embryonal in histology, which portends a good prognosis. Imaging, including CT, is recommended to assess for retroperitoneal lymphadenopathy, which can occur in up to 20% of patients. Interestingly, although ultrasonography is the imaging modality of choice for intratesticular pathology, paratesticular RMS on ultrasonography and even MRI may be elusive and often confused with other conditions such as epididymitis, adenomatoid tumor, and leiomyoma (15) (Fig. 91.3).

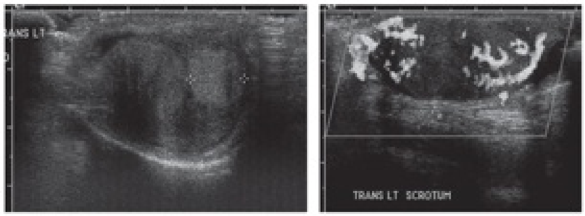

FIGURE 91.3 Scrotal ultrasound of a boy with paratesticular RMS showing mass (left) and flow to mass (right).

Vaginal and Uterine Rhabdomyosarcoma

Vaginal RMS typically presents with a vaginal discharge, bleeding, or a painful, expanding introital, anterior vaginal wall mass in the first few years of life. Uterine RMS typically presents as an abdominal mass originating from the uterine body or with vaginal bleeding from a cervical mass. These lesions carry an excellent prognosis due to their botryoid histology (2). Historically, these patients were treated with aggressive surgical resection with an anterior pelvic exenteration. With the advent of more efficacious chemotherapeutic agents, preservation of the vagina and uterus is paramount, and the patients are surgically resected only if persistence of disease after neoadjuvant chemotherapy, as determined by a postchemotherapy biopsy. Complications of treatment of vaginal and uterine RMS include vaginal stenosis, ureteral obstruction, intestinal stricture or fistula, and ovarian failure (Fig. 91.4).

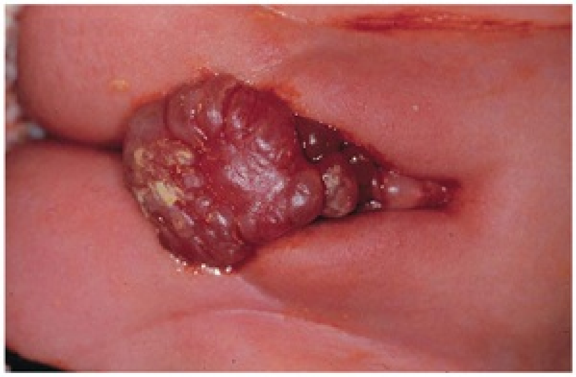

FIGURE 91.4 An 11-month-old in foster care with a 3-month history of enlarging vaginal mass. Resected with total response to chemotherapy. The patient is alive and with no evidence of disease after 17 years.

TREATMENT

The treatment of RMS involves the coordination of multimodal therapy including surgical resection, chemotherapy, and radiotherapy. A number of factors determine the treatment regimen including the specific pathologic and histologic subtype, primary site, biology, clinical stage of disease, and extent of resection. Many cooperative organizations, including the Soft Tissue Sarcoma Committee of the Children's Oncology Group (STS COG), Study for Malignant Mesenchymal Tumors of Société Internationale d'Oncologie Pédiatrique (SIOP-MMT), and Cooperative Weichteilsarkom-Studie (CWS), have defined specific risk-adapted treatment regimens (1).

According to the protocols set by STS COG, surgical resection or adequate biopsy is the initial treatment followed by adjuvant chemotherapy. Adequate tissue for a definitive diagnosis should be obtained, and if possible, the tumor should be removed without removing or potentially damaging the affected and adjacent organs (with the exception of paratesticular RMS, where the testis is removed inguinally with the tumor). This allows for characterization via IRSG risk group and will determine the subsequent treatment algorithm. If excision is not possible, primary chemotherapy should be given. In follow-up staging, a biopsy is needed during the "second-look" operation because the residual mass does not always represent tumor: The cancer can involute more rapidly than the supporting stroma. With pelvic tumors, definitive surgery aims to attain complete disease excision with clear margins but with an organ-sparing goal. If microscopic residual disease is found, it is treated with brachytherapy or external beam radiotherapy. Exenteration is reserved for patients who fail this protocol of chemotherapy, conservative surgery, and radiotherapy. In Europe, the approach is to give primary chemotherapy without initial local control (radiotherapy or surgery) and offer local therapy based on the initial chemotherapy response (16). SIOP treatment regimens advocate for neoadjuvant chemotherapy followed by completion surgical resection depending on the chemotherapeutic response.

Effective local therapy and control is essential for overall survival in patients with RMS (1). The dilemma between radical local treatment and preservation of residual organ function (bladder, vagina, testes/ovaries, and sexual function) is difficult but must be optimally determined to allow for the greatest cancer control and the least disruption of function. Certainly, the potential for bladder dysfunction in bladder-sparing procedures must be considered in the treatment algorithm. Other surgical procedures that have the potential to disrupt innervation and function, including extravesical reimplantation, have been associated with postoperative bladder dysfunction (3).

Radiotherapy, an alternative therapy, has been remarkably successful in decreasing the need for radical surgery to achieve a cure and has allowed for improved local control and relapse prevention (1). Newer therapies such as intensity-modulated radiation therapy, brachytherapy, and proton radiation allow for a minimization of treatment toxicity without compromising efficacy. In fact, multimodal treatment including limited surgical resection in combination with chemoradiation therapy may allow for preservation of function while maintaining cancer control. Radiation therapy has also been associated with bladder dysfunction in a dose-dependent manner, with both acute and chronic effects (3). The early effects include inflammatory changes in the bladder, which result in decreased bladder capacity, but it is typically reversible. The chronic effects are also dose-dependent and include lower urinary tract symptoms such as urgency, frequency, hematuria, and diminished bladder compliance secondary to fibrosis. The fibrosis is due to increased transforming growth factor-β expression resulting in increased collagen deposition in the muscle and subepithelial layers of the bladder. The difficulty with radiotherapy and bladder RMS is that because the tumors tend to be located at the bladder neck, even the lowest dose (41 Gray [Gy]) may significantly affect urinary continence. The long-term risk of radiation vasculitis, which is inevitably progressive, as well as possible bony pelvis deformity in these children is another issue to consider. Therefore, one must sometimes weigh whether preserving a bladder without an outlet is better than removing the bladder entirely (17). The final issue is that postradiation artifact makes subsequent biopsy very difficult to interpret, so it would make sense to delay radiation until the patient is free of gross disease. With radiotherapy, there is also an increased risk of a secondary neoplasm, often another sarcoma, typically in the radiation field. Current attempts at limiting radiation toxicity to adjacent organs involve both conformal radiotherapy and brachytherapy.

Chemotherapy is a mainstay in the treatment of RMS, including the combination of VAC, the mainstay chemotherapeutic regimen. Alternatively, doxorubicin has been implemented in addition or in lieu of dactinomycin and studied in extremely high-risk sarcomas (18). Albeit controversial, doxorubicin has been shown in IRSG III to have some benefit when added to the VAC regimen. Also, etoposide/ifosfamide has been shown to be effective for intermediate risk RMS (1). However, with complex chemotherapeutic regimens that also contain etoposide and cisplatin, the efficacy of doxorubicin alone has been difficult to ascertain. For refractory or relapsed RMS, topotecan/vincristine/doxorubicin has demonstrated remarkable response rates, albeit in a small number of patients (1). Chemotherapeutic agents such as alkylating agents (i.e., cyclophosphamide) can also have dose-dependent adverse effects on the bladder such as hemorrhagic cystitis, with gross hematuria, fibrosis, and bladder contracture, not to mention the increased risk of secondary bladder cancers. This condition is typically treated with mercaptoethane sulfonate (mesna), a compound that binds the cyclophosphamide metabolite, acrolein (3). The majority of patients have acute toxicity from the chemotherapy: Ninety percent developed myelosuppression, 55% developed significant infections, and renal toxicity was seen in 2% (8). Most relapses occur within 3 years of initial diagnosis (19). Late recurrences can occur in patients who are treated with chemotherapy alone. Of 883 patients, 10 developed a secondary cancer. Patients with preexisting renal abnormalities were at a higher risk of death (5% versus 1%). Relapse in group 3 patients (incomplete resection) was associated with a 22% chance of 3-year survival, compared to 41% in group 1 or 2 patients (localized disease or total gross resection) (8). Twenty-nine percent required sex hormone replacement, and 11% were shorter than expected (17) (Fig. 91.5).

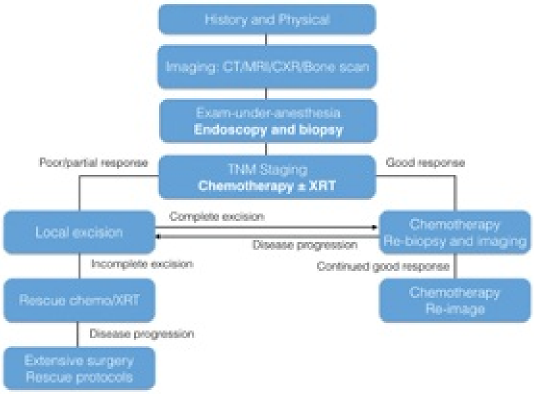

FIGURE 91.5 RMS treatment algorithm. *CT*, computerized tomography; *CXR*, chest X-ray; *MRI*, magnetic resonance imaging; *TNM*, tumor–node–metastasis; *XRT*, external beam radiation therapy.

Bladder and Prostate Rhabdomyosarcoma

Initial treatment of bladder and prostate RMS includes management of urinary obstruction with urethral catheterization for bladder outlet obstruction and ureteral stent placement if ureteral obstruction is present. Suprapubic drainage is not recommended secondary to the potential for tract seeding (3). Percutaneous nephrostomy tube placement may be indicated in cases where the trigone is distorted by a large mass and retrograde access cannot be gained. The treatment of bladder and prostate RMS is multimodal, with the goal of preserving bladder function by limiting complete resection. Unfortunately, in the majority of cases, partial resection is not a viable option given disease extent. Many centers recommend neoadjuvant chemoradiation, followed by partial surgical resection (i.e., bladder sparing) depending on response (2). With larger tumors having more extensive involvement, surgical reconstruction may be necessary including ureteral reimplantation and bladder augmentation in conjunction with partial cystectomy (3). A pretreatment re-excision may be necessary in patients who have been diagnosed endoscopically but have gross resectable residual tumor, microscopic positive margins, or unclear margin status. A second-look operation is indicated to confirm clinical and pathologic response to therapy and, if needed, to remove residual tumor in patients that achieve clinical complete or partial response.

The approach to partial or total cystectomy is similar to that for muscle-invasive transitional cell carcinoma. The initial step after opening the abdomen is to examine the retroperitoneum. Although a full retroperitoneal lymphadenectomy is not indicated because there is no therapeutic benefit, any suspicious lymph nodes along the vessels between the obturator fossa and the renal veins are removed. The next step is to properly stage the tumor by obtaining multiple frozen-section biopsies of the bladder around the area of the tumor. If these are negative and the tumor is amenable to partial cystectomy with a 2- to 3-cm margin, then the bladder does not need to be entirely removed. RMS is a nonencapsulated, infiltrative tumor, so attaining adequate margins is necessary.

If the tumor extends down the urethra, then the symphysis should be split to gain better access. After completing the distal dissection of the urethra, the symphysis is closed with long-term absorbable sutures. With this improved exposure, it is also possible to perform a nerve-sparing dissection. The placement of brachytherapy catheters for afterloading (to treat microscopic positive margins if needed) should be considered. Currently, pelvic exenteration is reserved for patients who have failed both chemotherapy and radiotherapy and who have tumors that invade both the bladder and the rectum.

The final surgical decision is whether to proceed with concurrent continent urinary reconstruction. It is not necessary to perform the reconstruction at the same time unless the patient is both motivated and able to perform clean intermittent catheterization to drain a urinary reservoir. For younger patients who are not ready to manage a urinary reservoir, a vesicostomy or low end cutaneous ureterostomies are viable options.

Radiation therapy is also a viable treatment option and is an integral part of the bladder-sparing approach with distinct risks of adverse outcomes including bladder dysfunction, which has been demonstrated urodynamically with reduced bladder capacity and abnormal voiding patterns (2) (Figs. 91.6 and 91.7).

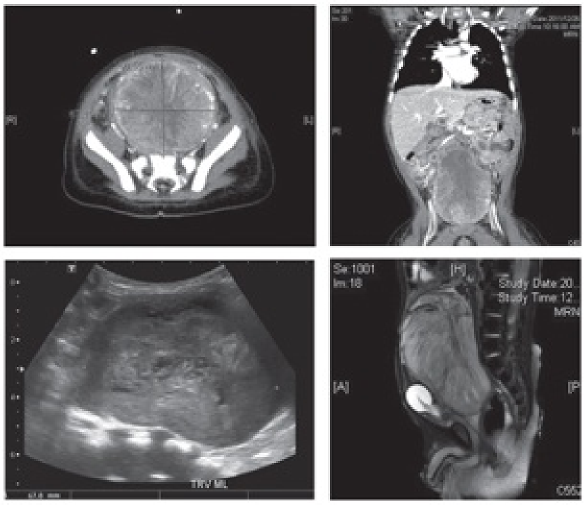

FIGURE 91.6 Radiographic images of an infant boy with pelvic RMS, axial CT (**top left**), coronal CT (**top right**), pelvic ultrasound (**bottom left**), and MRI (**bottom right**) demonstrating large pelvic mass.

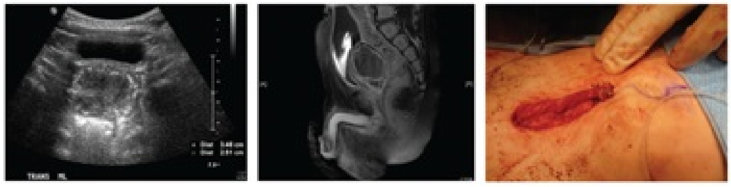

FIGURE 91.7 Postchemotherapy radiographic images of an infant boy with pelvic RMS, pelvic ultrasound (**left**) and sagittal MRI (**middle**) showing a residual pelvic mass, with the patient undergoing subsequent cystoprostatectomy and cutaneous ureterostomies (**right**).

Paratesticular Rhabdomyosarcoma

Treatment for paratesticular RMS includes radical inguinal orchiectomy. Frozen section of the proximal cord should be negative. A scrotal approach should be avoided because although chemotherapy often cures residual disease, some cases have required hemiscrotectomy due to tumor infiltration. An ipsilateral retroperitoneal lymph node dissection (RPLND) is recommended as part of routine staging before chemotherapy by the Children’s Oncology Group for all boys with stage I disease older than age 10 years, regardless of the findings on abdominal CT. The technique is identical to RPLND for retroperitoneal masses in patients with testis cancer. Usually, 60% of these tumors are localized and completely excised. Patients with positive lymph nodes are recommended to undergo intensified chemotherapy and pelvic and para-aortic retroperitoneal radiation with doses of 30 to 50 Gy (2,18). Chemotherapy has been shown to adequately clear microscopic disease (30% to 40% incidence). Survival rates have been estimated to be 90% with current multimodal therapy (2) (Fig. 91.8)

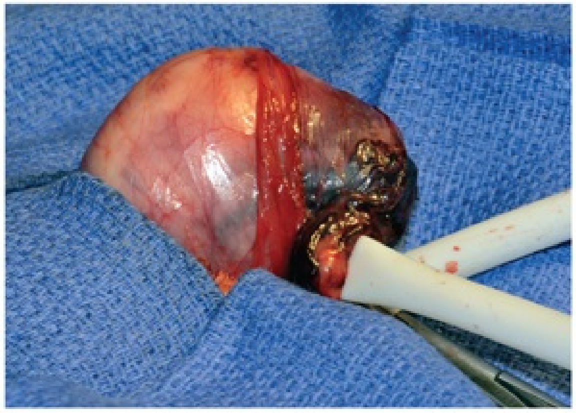

FIGURE 91.8 Paratesticular RMS, gross specimen. (Image courtesy of Dr. Kristina Suson, Children's Hospital of Michigan.)

Vaginal and Uterine Rhabdomyosarcoma

Primary chemotherapy followed by radiotherapy for relapse or nonresponders seems to be effective for these patients (20).

For surgical resection, the patient is placed in the lithotomy position, and the pelvis and vagina are prepared. For the initial resection, vaginoscopy is helpful in defining the limits of the tumor. Stay sutures and a small weighted vaginal speculum are helpful for exposure, as is a headlight for vision. Sharp excision of the tumor is carried out, staying away from the external sphincter, urethra, and bladder neck. The vaginal mucosa is closed with interrupted absorbable sutures. Hysterectomy is rarely carried out because uterine tumors are rare and tend to present in older girls (>10 years old) (Figs. 91.9 and 91.10).

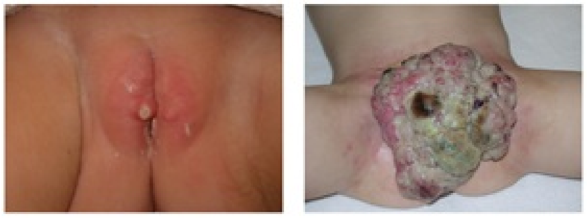

FIGURE 91.9 A 2-year-old girl with vulvar mass (left). Recurrence after wide excision despite multimodal therapy (right). Died of local disease without metastases.

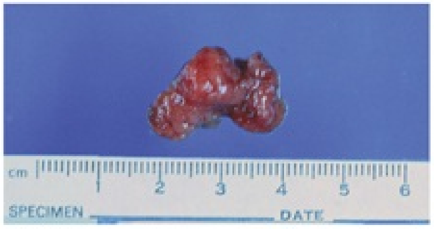

FIGURE 91.10 Gross specimen of a vaginal mass in a 4-year-old girl with painless bleeding found to be a vaginal papilloma.

Adolescent Rhabdomyosarcoma

When comparing adult and pediatric sarcomas, there are a number of differences regarding histopathology with adult tumors being leiomyosarcoma and lipomyosarcoma as compared to pediatric RMS. Adult sarcomas are typically managed upfront with radical surgery with a limited role of chemotherapy, whereas pediatric RMS is managed by a multimodal approach with an emphasis on chemoradiation to reduce the morbidity of radical surgery. RMS in children and adolescents is also more sensitive to chemoradiation therapy than the adult counterpart (21). Adolescent RMS is unique compared to “pediatric RMS” because males older than 10 years of age with paratesticular RMS should be managed with ipsilateral RPLND and those with metastatic disease are considered high-risk.

The second peak of the bimodal distribution for RMS includes the adolescent population, which comprises only 2% of new cancer diagnoses in this population (21). Paratesticular RMS is the most common genitourinary location and the third most common location for RMS in this population. Adolescent RMS is considered to be higher risk and portends a significantly worse outcome with higher recurrence and retreatment rates (21). This may be multifactorial including a greater percentage of more aggressive histologic type (alveolar RMS) as well as an increase in adverse events resulting in dose modification and resultant less efficacious therapy.

Unfortunately, with aggressive multimodal treatment, transient or permanent infertility is unavoidable. The discussion of potential alteration in fertility potential should be discussed before initiation of treatment to assess the role of preemptive fertility preservation. The mechanism for doing so involves direct preservation of germ cell lines via sperm banking or oocyte preservation. For this reason, it is prudent to include fertility specialists in the management team before initiation of cancer therapy. The gonadotoxic treatments that have the most significant effect on fertility include whole abdominal or pelvic radiation (>6 or 10 Gy, respectively, in female and >1.2 Gy to testes in males) and chemotherapeutic alkylating agents (21). Preventative options for females include oophoropexy (surgical relocation of ovaries to site outside of radiation field) and gonadotropin-releasing hormone agonists (protection from chemotherapy). Another option is embryo cryopreservation, but this may delay treatment. In males, preservation options include sperm banking with typical ejaculation, vibratory stimulation, electroejaculation, or surgical sperm collection before the start of therapy.

Pelvic radiation is part of the multimodal approach to childhood and adolescent RMS but has significant potential side effects associated with it including infertility secondary to direct gonadotoxic effects as well as uterine vascular insufficiency in girls, leading to adverse pregnancy outcomes. The radiation dose can be large ranging between 36 and 50 Gy, depending on the stage, grade, and degree of surgical control and can have a six- to eightfold risk of secondary malignancy (21). With patients treated with alkylating agents in addition to radiation, this risk is even greater with the most common secondary malignancy being skin cancer. Certainly, other potential secondary malignancies include bone, uterine, ovarian, and bladder cancer. This obviates the role of counseling patients in leading healthy lifestyles with avoidance of alcohol, smoking, and other drugs.

Chemotherapeutic agents also carry the potential for short- and long-term side effects depending on the agent used. Vincristine has been associated with peripheral neuropathy, with a higher incidence observed in adolescent patients and correlated with cumulative dosing (21). Platinum-based chemotherapy, including cisplatin is associated with nephrotoxicity, with both glomerular and tubular damage, and with a greater detrimental effect observed in the adolescent population (21). It is recommended to counsel these patients to avoid exacerbating factors such as nonsteroidal anti-inflammatory drugs, smoking, alcohol, or dehydration.

Emotional support is critical during this time period, particularly in the adolescents, an age group that is already transitioning into adulthood with all of the associated adjustments and challenges. Certain challenges must be addressed including self-image secondary to alopecia, changes in weight, mood, etc. Other issues include the psychosocial stress on interpersonal relationships and the psychological and socioeconomic implications on education, career plans, and employment. The tactic for the best outcomes involves adequate preparedness for the demands of treatment with adequate counseling via a multidisciplinary approach and providing good social support to increase compliance to treatment while simultaneously maintaining quality of life.

RISK STRATIFICATION

Intergroup Rhabdomyosarcoma Study Group Treatment Groups

Previous IRSG protocols employed a staging system (groups I to IV), reflective of disease extent and extent of initial surgical resection (3). The current protocols risk stratify the patients into low-, intermediate-, and high-risk groups. Risk stratification and outcome is a complex process that is dependent on multiple variables including extent of excision, the presence of metastatic disease, origin site, age, and the histologic and genetic characteristics.

The *low*-risk group includes patients with localized embryonal RMS at favorable sites (paratesticular and vaginal, including botryoid RMS) and completely resected or microscopic residual disease in patients with RMS at unfavorable sites. The patients may be upstaged to an intermediate-risk group if there is confirmation of alveolar or undifferentiated RMS. Therapy begins with chemotherapy (VAC) for four cycles and a subset of patients go onto four cycles of actinomycin D and vincristine, whereas the other subset is continued on actinomycin D and vincristine for an additional 13 weeks (3).

The *intermediate*-risk group includes patients with embryonal RMS at unfavorable sites (bladder/prostate) and those with gross residual disease, patients that are younger than 10 years of age, and patients with nonmetastatic alveolar RMS or undifferentiated RMS. Given the higher risk associated with this group, the potential for bladder-sparing procedures is diminished to 25% to 45% (3).

The *high*-risk group is composed primarily of patients with alveolar RMS and undifferentiated RMS as well as patients who are older than 10 years of age with metastatic embryonal RMS. The treatment algorithm for this group includes delayed surgical excision after stabilization of metastatic disease with systemic therapy at 3 to 6 months after initial diagnosis. Radical excision is only indicated if no residual metastatic disease is present. Chemotherapy in the high-risk group has not had an impact on prognosis, but agents such as ifosfamide and etoposide have been incorporated along with radiation therapy upfront to assess response in previously untreated patients (3) (Tables 91.3 and 91.4).

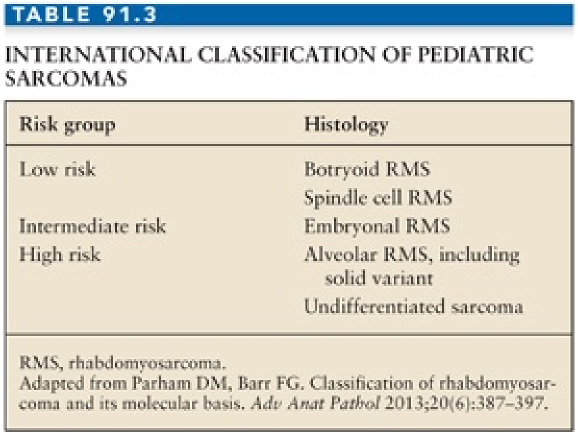

TABLE 91.3

INTERNATIONAL CLASSIFICATION OF PEDIATRIC SARCOMAS

Risk group	Histology
Low risk	Botryoid RMS
	Spindle cell RMS
Intermediate risk	Embryonal RMS
High risk	Alveolar RMS, including solid variant
	Undifferentiated sarcoma

RMS, rhabdomyosarcoma.
Adapted from Parham DM, Barr FG. Classification of rhabdomyosarcoma and its molecular basis. *Adv Anat Pathol* 2013;20(6):387–397.

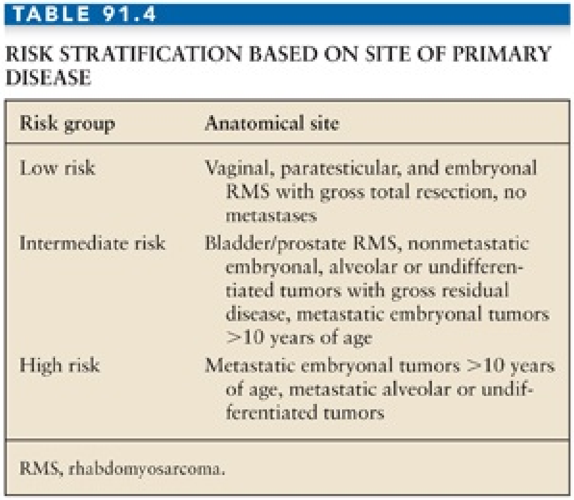

TABLE 91.4

RISK STRATIFICATION BASED ON SITE OF PRIMARY DISEASE

Risk group	Anatomical site
Low risk	Vaginal, paratesticular, and embryonal RMS with gross total resection, no metastases
Intermediate risk	Bladder/prostate RMS, nonmetastatic embryonal, alveolar or undifferentiated tumors with gross residual disease, metastatic embryonal tumors >10 years of age
High risk	Metastatic embryonal tumors >10 years of age, metastatic alveolar or undifferentiated tumors

RMS, rhabdomyosarcoma.

OUTCOMES

The long-term prognosis of RMS has improved in recent years through the implementation of multimodal therapy and the risk-based treatment protocols by the IRSG (1). The 5-year survival is now more than 70% up from 25% in the 1960s. Current long-term survival probabilities were found to be highest for younger children, patients with localized disease, and embryonal histology, whereas poor prognosis has been associated with diagnosis during infancy and adolescence, metastatic disease at time of presentation, and alveolar histology. For patients who survived 5 years or greater, the conditional 10-year survival rate is as high as 85% (22). Patients with advanced disease (group III/IV) and large primary tumor at diagnosis are at the highest risk of late events (disease recurrence, second malignant neoplasm, or death from other causes) after having being alive and event-free at 5 years (23).

Metastatic RMS is a unique subset of patients treated with multimodal therapy with the potential for high-dose end-intensification therapy with stem cell support at select centers. In a large retrospective review, the 3-year overall survival rate and failure-free survival rate were 35% and 29%, respectively. Patients who had embryonal histology, metastases confined to the lung, and age younger than 10 years fared better with a 3-year overall survival of 100% (24).

Due to the implementation of multimodal treatment, there are established side effects from each of the treatment modalities. Long-term nephrotoxicity from chemotherapeutic agents is difficult to assess, but at 10 years follow-up in patients who have undergone ifosfamide therapy, 89.5% have normal renal function and 78.5% have normal glomerular filtration rate. Other potential side effects include hypomagnesemia and hypophosphatemia, which are rare, along with glycosuria and proteinuria, which are relatively more common. Older age at diagnosis and length of treatment interval were correlated with abnormal glomerular filtration rate (25). Older age also correlated with increased peripheral nervous system toxicity, yet less hematologic toxicity (neutropenia, thrombocytopenia, anemia, and infection) and less 5-year event-free survival rate compared to younger patients receiving the same amount of chemotherapy (vincristine, actinomycin-D, and cyclophosphamide [VAC]; vincristine, actinomycin-D, and ifosfamide [VAI]; vincristine, ifosfamide, and etoposide [VIE]) (26).

Radiation therapy can have direct effects on the bladder, including inflammatory infiltrates causing cystitis, fibrosis, cellular atypical, hematuria, fistula formation, necrosis, and even bladder rupture. There have been reports of repeat spontaneous bladder rupture years after radiation therapy following therapy for RMS (27). Complications such as bladder rupture should prompt urologic assessment, including urodynamics after both bladder-sparing procedures and radiation treatment for

RMS. Preservation of erectile function in children and adolescents has been shown to be feasible despite multimodal treatment including radical surgery with urinary diversion, chemotherapy, and radiotherapy (28) (Fig. 91.11).

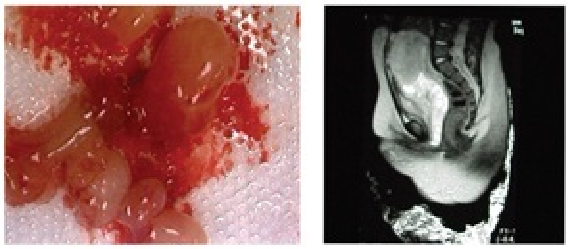

FIGURE 91.11 A 1-year-old girl with asymptomatic gross diaper spotting (**left**) with normal examination and MRI (**right**) revealing bladder lesions. Endoscopic biopsy revealed RMS, treated with chemotherapy but repeat examination under anesthesia showed persistent active disease. The patient ultimately had a subtotal vaginectomy with sigmoid neovagina and no radiation. She is alive and with no evidence of disease after 20 years.

Bladder and Prostate Rhabdomyosarcoma

The main advances in the management of bladder and prostate RMS include improvements in chemoradiation therapy and the resultant rise of bladder-sparing surgery with the goal of preserving function while maintaining cancer control. The third IRSG included intensified chemotherapy and 6 weeks of radiotherapy, increasing the functional bladder salvage rate from 25% to 60%. In the fourth IRSG, VAC was shown to be as effective as two other three-drug regimens (8). On a second-look procedure, half of patients were managed with biopsy, 30% had partial cystectomy, 13% had cystoprostatectomy, and the remainder underwent either cystectomy or prostatectomy alone (29). For persistent disease, the patients were irradiated. At 24 weeks, a third operative evaluation was performed with consideration for exenteration. The patients with embryonal pathology had an 83% 3-year failure-free survival, compared to 40% in those with alveolar pathology. All patients with metastatic (group 4) prostate disease died. Renal function, as assessed by serum blood urea nitrogen and creatinine, was normal in 95%, although 29% of patients had abnormal renal scans (30). Bladder function (as assessed by questionnaire) was normal in only 40% of patients (29).

With the increasing trend in bladder-sparing operations, the pertinent question is how functional are these bladders and does bladder preservation affect event-free and overall survival (3). The fourth IRSG group on bladder preservation demonstrated that under half of the patients had normal bladder function as determined by history, but over 70% of patients achieved event-free survival, with over 80% of patients achieving overall survival (29). The less aggressive multimodal approach of bladder-sparing operations in conjunction with chemoradiation therapy has shown promising results on posttreatment bladder function, with one study demonstrating that almost half of the patients were asymptomatic with normal urodynamics, whereas the remaining patients had either minor yet tolerable urologic complaints or complaints with urodynamic findings of reduced bladder capacity. Only one patient in this series required cystectomy with urinary diversion secondary to refractory urologic complaints (31).

In a larger international series, 48% of patients underwent biopsy alone, 30% had partial cystectomy, and 21% had complete cystectomy. Of the male patients, only 24% underwent prostatectomy. Bladder function was normal in 69% of patients treated with biopsy alone and 73% of patients who underwent partial cystectomy. Neither of these series utilized urodynamic studies to fully evaluate bladder function. Renal function was abnormal in 40% of patients, and bowel function was abnormal in 13% (32).

Certainly bladder-sparing procedures when appropriate can minimize alterations to lifestyle; however, many of these patients ultimately require cystectomy or more aggressive surgical treatment secondary to significant alterations in normal bladder function due to small-capacity, noncompliant bladders resulting in refractory urinary frequency or incontinence. Fortunately, there are many reconstructive options including bladder augmentation and continent urinary diversion given the fact that long-term survival from this condition is more commonplace (33). Orthotopic urinary diversion has been shown to be technically feasible with long-term outcomes that offer good quality of life with preserved daytime and nighttime continence and ability to void spontaneously (34). A limitation in urinary reconstruction using bowel segments is prior exposure to radiation therapy, which may limit the viability of this tissue for use in urinary reconstruction (33).

Bladder and prostate RMS managed with neoadjuvant chemotherapy, an organ-sparing approach initially, radical approach for positive margin status, and radiotherapy for residual disease after radical approach still has a very high potential for cure with preservation of continence and erectile and renal function (35). Urinary tract reconstruction may be safely performed initially with radiation limited to patients with residual and metastatic disease to reduce radiation-induced morbidity (35) (Fig. 91.12).

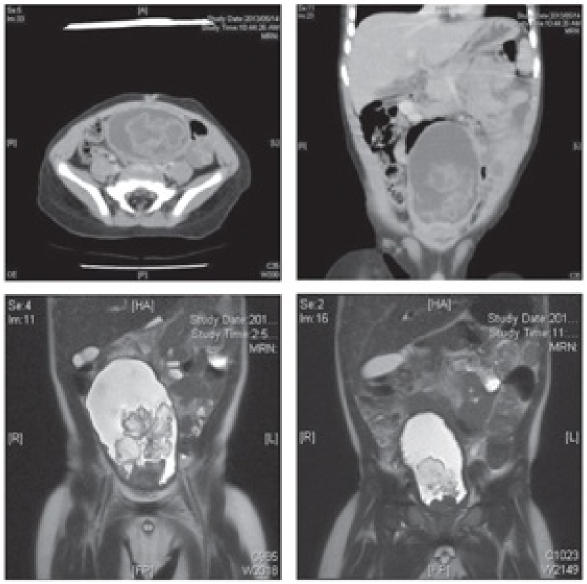

FIGURE 91.12 Prostate and bladder RMS shown with axial CT (top left), coronal CT (top right), and coronal MRI (bottom left) demonstrating bladder mass and post-chemotherapy imaging with coronal MRI (bottom right) demonstrating mass shrinkage.

Paratesticular Rhabdomyosarcoma

A significant factor that influences prognosis in paratesticular RMS is age. The biologic activity of the tumor is different between the neonate and the teenager (90% versus 63% failure-free survival at 3 years). In previous studies, all patients underwent RPLND (8). However, Olive et al. (36) showed in 1984 that of 19 patients with clinical stage I disease, 17 were cured with adjuvant chemotherapy alone. This showed that chemotherapy could eradicate microscopic retroperitoneal disease, making RPLND unnecessary. In the fourth IRSG, RPLND was not recommended, leading to a significant understaging of disease and a decrease in failure-free survival rates, primarily in patients >10 years old because patients with negative CT scans did not receive radiation. Thirty percent of those patients who were clinically stage I and over 10 years of age required retreatment. In contrast, because the outcome for stage I disease in those under 10 years of age was so good in IRSG IV, those patients who are <10 years old and have stage I disease and negative abdominopelvic CT are treated with VA (vincristine/dactinomycin) only in IRSG V, whereas all patients with stage I disease who are 10 years or older undergo RPLND regardless of CT findings. Group 2 tumors (positive lymph nodes on pathology) are treated with radiotherapy and VAC. The 3-year failure-free survival rate was 81% for group 1 tumors overall, but those patients >10 years old had only a 63% survival rate.

Vaginal and Uterine Rhabdomyosarcoma

Surgery and chemotherapy cure most cases of vaginal RMS. In the overall IRSG I to IV experience, 42% of patients were treated with surgery and chemotherapy, 19% required additional radiotherapy, 21% were treated with biopsy and chemotherapy alone, and 12% were managed with biopsy, chemotherapy, and radiotherapy (37). In IRSG IV, only 19% of patients required wide excision of the tumor. Primary treatment with VAC chemotherapy is usually successful, and a biopsy 8 to 12 weeks after chemotherapy is recommended. Pelvic lymph node dissection is not necessary. Radiotherapy should be used only for persistent disease or relapse (38). Rhabdomyoblasts on biopsy are evidence of chemotherapy response, and therefore further chemotherapy, instead of resection, is the proper treatment (39).

The majority of girls diagnosed with genital tract RMS have localized disease with embryonal RMS located in the vagina in the girls younger than 9 years of age, closely followed by the uterus/cervix in the girls older than 9 years of age. Superior survival is seen in those with embryonal histology and early stage presentation (40).

Dilemma of Mature Rhabdomyoblasts

The increasing trend of organ-sparing surgery has resulted in functional preservation while concurrently warranting close surveillance, sampling of the residual tissue, and further resection of involved sites, if needed. The assessment of the sampled specimens can reveal dramatic changes in the histopathologic appearance with the potential for maturation of the tumor cells, forming “mature” rhabdomyoblasts. This finding presents a diagnostic and prognostic conundrum (39). The mature rhabdomyoblasts are terminally differentiated muscle cells and have been shown to indicate apparent cure or a better prognosis, thereby not necessitating further treatment, including radical surgery. Mature rhabdomyoblasts have been shown not be malignant but rather a sign of response to treatment demonstrating that the malignant cells have disappeared (41). Histologically, these mature cells exhibit a large, smooth nucleus, no significant pleomorphism, no mitotic activity, and the absence of cell clusters suggestive of growth from a common precursor (3). Despite the evidence that supports the benign nature of these cells, it is prudent to continue close surveillance of these patients with follow-up imaging and endoscopy.

CONCLUSIONS

The management of childhood RMS remains one of the most controversial topics in pediatric urologic oncology. An improved understanding of the biologic disease process of RMS has allowed for the development of multimodal therapy, thereby minimizing the adverse effects of overly aggressive surgical resection and chemoradiation treatment, allowing for optimal cancer control with minimization of organ dysfunction. Although all agree that a combination of surgery, chemotherapy, and radiotherapy is best, the optimal timing and extent of the three treatment modalities remain unclear. The future of childhood RMS treatment involves a balance between maximizing oncologic control, life expectancy, and quality of life via a multimodal approach while minimizing morbidity via tissue-sparing and minimally invasive procedures. (42).

COG = Children’s Oncology Group
CT = computed tomography

CWS = Cooperative Weichteilsarkom-Studie (CWS)
Gy = Gray
GFR = glomerular filtration rate
IRSG = Intergroup Rhabdomyosarcoma Study Group
MRI = magnetic resonance
PET = positron emission tomography
RMS = rhabdomyosarcoma
RPLND = retroperitoneal lymph node dissection (RPLND)
TNM = tumor–node–metastasis
VAC = vincristine, actinomycin-D, and cyclophosphamide
VAI = vincristine, actinomycin-D, and ifosfamide
VIE = vincristine, ifosfamide, and etoposide

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CHAPTER 92 VESICOURETERAL REFLUX

MARK R. ZAONTZ AND CHRISTOPHER J. LONG

Until the 1980s, the treatment for reflux was dominated by ureteral reimplantation, with cure rates approaching 98%. However, multicenter studies have since shown that not all reflux is created equally. Lower grades (I to II) of reflux have high spontaneous resolution rates, and these patients could be followed at least initially with observation or medical management with continuous low-dose prophylactic antibiotics and yearly reassessment. Higher grades of reflux (III to V) are associated with a higher incidence of renal scarring and lower rates of spontaneous resolution and warrant closer follow-up. These findings have led to a field change in management of vesicoureteral reflux (VUR).

Surgical correction of reflux has been shown to decrease the incidence of urinary tract infection (UTI) but may not prevent progression of reflux nephropathy when present. Reflux in the presence of sterile urine in general does not cause renal damage, although reflux in the presence of UTI and/or lower urinary tract obstruction can lead to renal scarring.

Boys, in general, present with higher reflux grades than girls of the same age and are more likely to develop a UTI, but boys also have a higher spontaneous resolution rate compared to girls. Studies showing that circumcised boys with low grades of reflux rarely get UTIs have led to a nonoperative algorithm in this group of patients. Circumcision can be offered to boys with reflux as a protective measure.

Reflux is commonly linked with voiding dysfunction in children. Screening assessment for any signs of abnormal voiding patterns (wetness, urgency, constipation, penile pain, dysuria, holding maneuvers) should be performed in all potty-trained children diagnosed with reflux. Recent evidence has shown high spontaneous cure rates for refluxing children when bladder bowel dysfunction is treated with urodynamics and biofeedback techniques. Conversely, children with significant voiding dysfunction have higher failure rates than those with normal bladder function, particularly when endoscopic bulking agents are used (1). While most cases of reflux are congenital in nature and considered primary reflux, increased intravesical pressure due to anatomic bladder outlet obstruction (posterior urethral valves) or functional causes such as neuropathic bladder/voiding dysfunction can lead to what is termed *secondary reflux*. Patients suspected of having secondary causes of VUR need further assessment prior to intervention.

Sampson (2) in the early 1900s proposed a flap-valve mechanism for the ureterovesical junction that was corroborated by Gruber (3), who found that those ureters with shorter intravesical segments were more prone to have reflux and therefore have a defective flap-valve mechanism. Stephens and Lenaghan (4) added that the deficiency of the intravesical ureter's longitudinal muscle with or without a deficiency in ureteral tunnel length was also responsible for the reflux phenomenon. From a surgical perspective, we have learned that a 5:1 ratio of ureteral tunnel length to ureteral lumen diameter is necessary to prevent reflux. Care must be taken to mobilize the ureter such that the repair is not under tension, a straight trajectory through the bladder wall is maintained, that the ureter is sufficiently spatulated to prevent meatal stenosis, and that the blood supply is preserved throughout the dissection. Certainly meticulous technique is required to minimize trauma to the tissue. These guiding principles are fundamental to successful surgical correction of VUR.

DIAGNOSIS

Today, thanks in great part to widespread use of antenatal screening, reflux is often diagnosed prior to the development of a urinary infection. As a result, pyelonephritis and subsequent renal scarring may be avoided by promptly beginning antibiotic prophylaxis after delivery. Prenatal ultrasound (US) findings suspicious for VUR include bilateral hydronephrosis, bladder thickening, and/or ureterectasis, all of which should prompt postnatal voiding cystourethrogram (VCUG) study to rule out reflux. The remainder of patients will be discovered after workup for UTI. Presenting symptoms in neonates can be nebulous and may include malaise, fever, vomiting, diarrhea, or failure to thrive. Toddlers and young children may have more typical symptoms, such as fever, frequency, urgency, dysuria, foul-smelling urine, incontinence, or abdominal and/or back discomfort. Once reflux is diagnosed, it is graded according to the International Study Classification (Fig. 92.1) (5). This system is based on the radiographic appearance of the ureter and collecting system during a VCUG. Follow-up studies to assess for resolution or progression are in general done using either VCUG or nuclear cystography at yearly intervals for low-grade reflux or longer intervals for higher grade reflux.

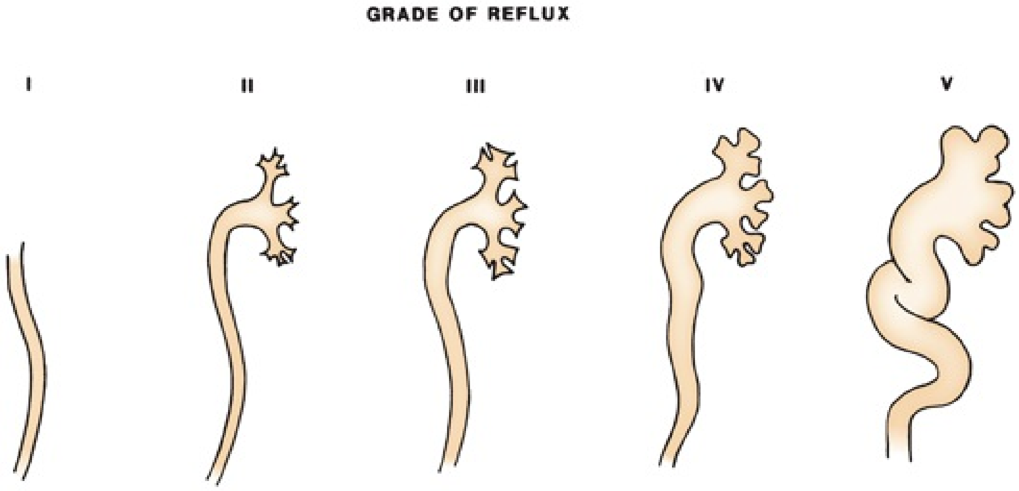

FIGURE 92.1 International classification of VUR. Grade I, into the nondilated ureter; grade II, into the pelvis and calices without dilation; grade III, mild to moderate dilation of the ureter, renal pelvis, and calices with minimal blunting of the fornices; grade IV, moderate ureteral tortuosity and dilation of the pelvis and calices; and grade V, gross dilation of the ureter, pelvis, and calices and loss of papillary impressions and ureteral tortuosity.

In 2011, the American Academy of Pediatrics (AAP) updated its guidelines for UTI workup in children ages 2 to 24 months (6). These guidelines do not apply to newborns and children outside these age ranges. It is critical that a urine culture and urinalysis be obtained in all cases of suspected UTI or workup for fever of unknown origin. A urinalysis alone is unacceptable as it only alludes to the presence of UTI and at best is only 80% accurate in diagnosis. On urinalysis, pyuria suggests an acute infection (along with positive leukocyte esterase and nitrite), whereas a positive culture is now defined as >50,000 colony-forming units per mL. According to the AAP guidelines, US of the kidneys and bladder is indicated after the first UTI. VCUG is obtained for bilateral hydronephrosis, bladder thickening, renal scarring, or evidence of obstruction. Otherwise, it is reserved for patients that develop a second febrile UTI. VCUG study at initial UTI remains a controversial topic as the American Urological Association clinical guidelines leave this as an alternative for the clinician.

A major contention with the AAP guidelines is reserving VCUG study until there is either an abnormal US or the development of a second UTI. The sensitivity of US for detecting renal scarring in the literature ranges from 22% to 65%, which certainly questions US as the screening tool of choice (7). Although this approach decreases the number of children undergoing invasive testing, it potentially delays intervention and definitive therapy in those who would benefit from it (8). AAP guidelines currently do not include recommendations for ^{99m}Tc-labeled dimercaptosuccinic acid (DMSA) scan even though it remains the best available study to assess focal pyelonephritis and renal scarring.

The “top-down approach” is an alternative to the given algorithm and limits VCUG study to patients with evidence of renal damage (pyelonephritis, renal dysplasia, renal scarring). Patient evaluation after first febrile UTI consists of US and a DMSA scan to determine if the kidney has been engaged in the infection. If the scan is negative, then a VCUG can be obviated. Proponents for this approach cite a 50% decrease in invasive testing for what will likely be clinically insignificant reflux. Although this is an attractive option, a second febrile UTI would still warrant evaluation with a VCUG.

Cystoscopy has little value in predicting the presence or cessation of reflux based on ureteral orifice configuration or location. Factors such as tunnel length or the presence of incomplete versus complete duplication anomalies will guide the surgeon to choose an appropriate technique, open or endoscopic. PIC cystogram (positioning the instilled contrast at the ureteral orifice) is rarely indicated but may be useful in patients with recurrent febrile UTI in the absence of VUR on VCUG (9).

Screening for reflux in asymptomatic siblings should be limited to renal bladder US, reserving VCUG for children with an abnormal US (10). The majority of asymptomatic reflux discovered in siblings spontaneously resolves.

INDICATIONS FOR SURGERY

Indications for surgical correction of VUR include the following:

- Older patient with clinically significant reflux
- Breakthrough UTI
- Persistent high grade of reflux (III to V)
- Presence of renal scarring or decreased function
- Noncompliance with prophylaxis
- Family concerns for repeated invasive testing and long-term prophylaxis

Findings from the International Reflux Study in Children lend support toward surgical intervention in grade III and IV reflux, with the majority of these patients failing to resolve their reflux (11). Other studies have supported these findings, with rates of resolution of reflux ranging from 10% to 33% in patients with grade IV reflux (12,13). Surgery is in general recommended for grade V reflux because of the low likelihood of spontaneous resolution. Recurrent breakthrough urinary infection while on adequate antibiotic prophylaxis is the sine qua non for surgical intervention because otherwise these children are at high risk for recurrent pyelonephritis and renal damage.

ALTERNATIVE THERAPY

There are several factors that must be taken into consideration for appropriate management of VUR and should be individualized to the patient: reflux grade, degree of renal scarring, volume at onset of reflux, patient age, presence or absence of bladder outlet obstruction, compliance of the patient/family on prophylactic antibiotics, ability to remain infection-free while on prophylaxis, and presence/absence of associated bladder and bowel dysfunction. Reflux may spontaneously resolve, the majority of which occurs by 5 to 7 years of age. There is an inverse relationship between reflux grade and likelihood of spontaneous resolution; the lower the grade of reflux and younger age of diagnosis, the higher the likelihood for spontaneous resolution. Boys are more likely to resolve than girls, and unilateral reflux is statistically more likely to resolve than bilateral reflux. Medical management consists of daily low-dose antibiotic prophylaxis, usually a sulfa-based compound or nitrofurantoin at bedtime. In addition to antibiotics, bladder training with biofeedback in cases of dysfunctional voiding is instituted. This is designed to improve bladder emptying at regular intervals, obviate bladder-sphincter dyssynergia, and maintain a minimal postvoid residual. This may require a variety of teaching aids and the use of pharmacotherapy such as anticholinergics and/or alpha antagonists. Equally important is to improve bowel function in the presence of constipation.

SURGICAL TECHNIQUE

Once the decision is made for surgical intervention, there are a myriad of operative procedures available depending on one’s preference and comfort level. The existing techniques are divided into endoscopic injection: the open approach via extravesical, intravesical, or a combination of the two; and the minimally invasive correction.

Endoscopic Surgery

Teflon was the first bulking agent used for endoscopic correction of reflux. Although the results were encouraging, later studies showed that there was migration of the Teflon particles to the lung, lymph nodes, and brain as well as the finding of granuloma formation; this resulted in the search for more biocompatible bulking agents (14). These have included both autologous agents (fat, blood, human collagen, bladder muscle cells, and ChondroGEL) and nonautologous agents (silicone, BioGlass, polyvinyl alcohol, and dextranomer microspheres). Deflux (dextranomer microspheres) has emerged as the agent of choice for bulking agents and at present is the sole agent approved by the U.S. Food and Drug Administration. Endoscopic surgery technique for reflux will be discussed in another chapter.

Extravesical Approach

Lich (15) and Gregoir (16) in the 1960s separately developed the extravesical approach to correct reflux. Further modifications of this approach have yielded success equal to that of the intravesical techniques (17). The benefits of this procedure are several: (a) The surgery is performed entirely outside of the bladder mucosa and as such avoids gross hematuria and irritable postoperative voiding problems such as urgency and bladder spasms, (b) catheter drainage of the bladder is brief, (c) wound drains are avoided, and (d) ureteral stents are eliminated. A further advantage of this technique is that hospital stay is brief, averaging 1.5 days in our hands, thus decreasing overall hospital costs.

The patient is placed in the supine position, and the bladder is catheterized on the field and filled to about one-third to one-half of its estimated capacity with sterile saline. This facilitates dissection of the detrusor muscle from the mucosa. The bladder may be further filled or emptied throughout the procedure. The surgical procedure begins similarly to the intravesical approach with a Pfannenstiel incision. A Dennis–Browne retractor is then placed over moistened gauze pads, and the bladder is carefully mobilized and rotated anteromedially, exposing the perivesical space. Care should be taken to avoid entering the peritoneum during this maneuver. Placing an appropriate-sized Deaver retractor to help keep the rotated bladder in place will greatly facilitate locating the obliterated hypogastric vessel. This vessel is tied off with 3-0 polyglycolic acid suture, and the most lateral tie is tagged to help expose the ureter, which lies just beneath this vessel. In cases of bilateral detrusorrhaphy, the obliterated hypogastric vessel need not be tied off but simply recognized for ease of finding the underlying ureter. The detrusor innervation courses posteromedial to the ureter and care must be taken to limit dissection in this part of the bladder. This minimal dissection technique as described, as well as limiting the dissection of the extravesical submucosal tunnel, may help prevent significant denervation and avoid postoperative urinary retention. The ureter is carefully mobilized and encircled with a vessel loop (Fig. 92.2). The ureter is freed up to its entry point into the bladder. During this maneuver, the Deaver retractors may need to be reset to keep the ureter in the middle of the operative field. A tennis racket incision is made around the ureteral detrusor hiatus and deepened until the ureter is only attached to the mucosa. The detrusorotomy is then extended to create a 3- to 5-cm trough. It is helpful to place stay sutures of 3-0 polyglycolic acid on the detrusor edges to facilitate dissection of the detrusor muscle off the mucosa. All vessels encountered during this dissection are tied off with 4-0 or 3-0 polyglycolic acid suture, and great care is exercised to avoid making a rent in the bladder (Fig. 92.3). If this occurs, immediately close the defect with the 6-0 chromic catgut. The dissection should be generous enough to lay the ureter in the newly created trough and permit the detrusor muscle to be closed over the ureter without too much tension. To complete the detrusorotomy, dissection is extended toward the bladder neck beyond the distalmost detrusor incision to allow placement of the advancement sutures. The first limb of the two sutures is through the detrusor (outside-in), entering at the distal limit of the trigonal musculature and exiting in the plane between the mucosa and detrusor. The second limb of the suture is placed through the ureteral muscle, and the final limb of the suture is back through the detrusor (inside-out). Tying the pair of "vest- type" sutures advances the ureter on the trigone, creating a longer submucosal tunnel, and anchors the ureteral orifice distally, preventing proximal migration of the ureter (Fig. 92.4). The remaining detrusor defect is closed over the ureter in two layers; the first is a running layer and the second is an interrupted Lembert suture, both using 4-0 polyglycolic acid suture. Care must be exercised to avoid making the ureteral hiatus too snug. The exit point for the ureter should be able to admit a hemostat between the detrusor and the ureter easily (Fig. 92.5). No perivesical drains or ureteral stents are used, and the Foley catheter is removed the following morning.

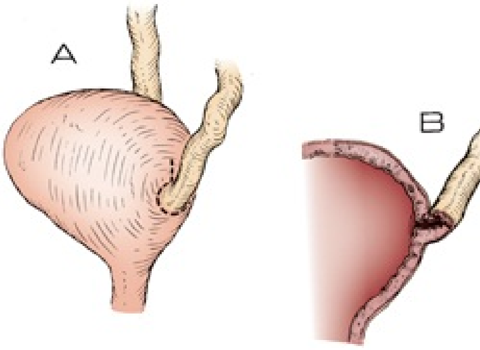

FIGURE 92.2 **A:** After ureteral mobilization, detrusor is incised (*broken lines*) at level of ureteral hiatus. **B:** Sagittal section demonstrates ureteral hiatus.

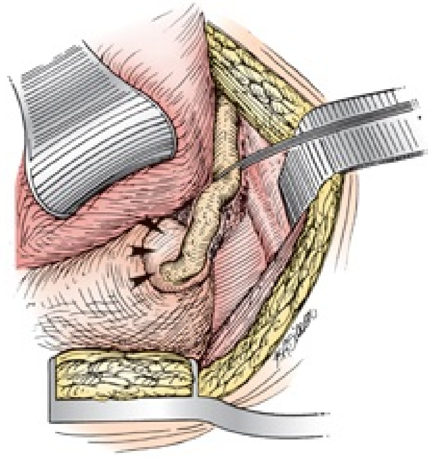

FIGURE 92.3 Ureter contiguous with detrusor mucosa (*arrowheads*).

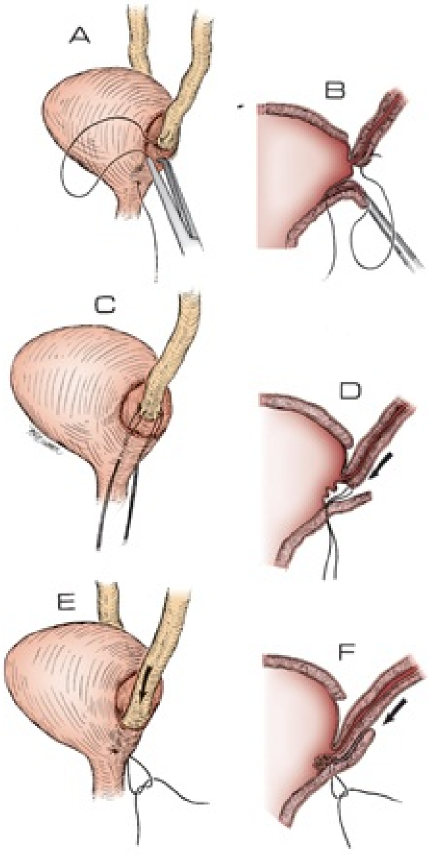

FIGURE 92.4 **A:** Bladder mucosa is elevated off bladder wall muscle and vest-type sutures are placed. **B:** Sagittal section shows suture passing between undermined mucosa and detrusor. **C:** Alignment of vest sutures after placement. **D:** Sagittal section demonstrates appropriate positioning of sutures. **E:** Tying vest sutures advances and anchors ureter onto trigone. **F:** Sagittal section of ureteromeatal advancement (arrow reflects advancement of distal ureter within the detrusor tunnel).

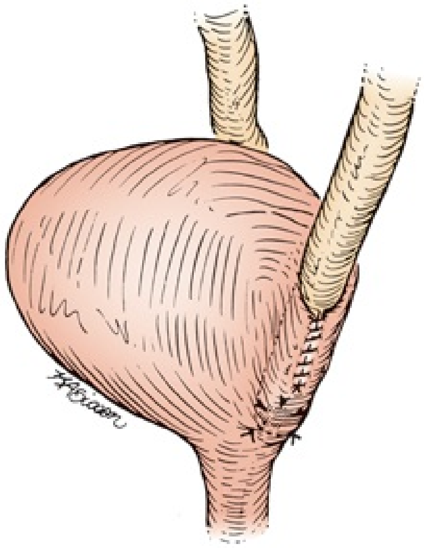

FIGURE 92.5 Closure of detrusor flaps over ureter allows for long submucosal tunnel and completes detrusorrhaphy.

Complete and incomplete ureteral duplication may also be approached extravesically. In this case, cystoscopy at the time of surgery is recommended to visualize the ureteral orifice location with respect to location and proximity to each other as well as distance to the bladder neck. A ureteral orifice that inserts too closely to the bladder neck will impede the surgeon’s ability to perform an advancement, in which case another technique is more appropriate.

Finally, as we continue to push the envelope with minimally invasive procedures, the extravesical technique can be approached in select patients via a small transverse inguinal incision to achieve access to the ureter. In these cases, it is advantageous to perform a cystoscopy to pass a temporary ureteral stent up the refluxing ureter to aid in initial identification. The procedure is otherwise essentially the same as already described, although some institutions are obviating the advancement portion of the procedure.

Intravesical Approach

One of the earlier and still highly popular and successful techniques to correct reflux is the Politano–Leadbetter approach (18). This procedure is performed entirely intravesically and avoids mobilization of the bladder as seen in the extravesical approach. Once the bladder is exposed via the technique previously described for the extravesical approach, it is opened in the midline between 3-0 chromic catgut stay sutures. The bladder is packed with moist 4 inches × 8 inches gauze pads to allow cephalad retraction of the bladder, which exposes the ureteral orifices. This is further facilitated with the placement of a Dennis–Browne retractor with the curved blades within the bladder over moist sponges. The ureteral orifice is identified and intubated with a 5Fr feeding tube and secured with 4-0 or 5-0 silk sutures to allow tenting of the ureter when gently pulling on the feeding tube. As with all intravesical repairs, the ureter is mobilized in similar fashion (Fig. 92.6). An incision is made to score the mucosa around the orifice. This can be done with a scalpel, tenotomy scissor, or, as we prefer, the cutting current of the Bovie with a Colorado tip, which provides a precise dissection. Carefully, using long tenotomy scissors, vascular forceps, Kittner dissector, a right-angle clamp, and judicious use of the cautery unit, the muscular attachments to the ureter are taken down through the wall of the bladder. As the dissection proceeds proximally, we have employed the use of a no. 3 Freer elevator along the posterior surface of the ureter, which further aids in mobilization. It is critically important to stay outside of the adventitia of the ureter to avoid devascularization during this dissection. The peritoneum is encountered and gently swept back off the ureter to avoid injuring the bowel during the relocation of the ureter. A hernia retractor or a very thin Deaver helps to better expose the peritoneum and extravesical attachments to the ureter. In the male patient, care must be taken to avoid injury to the vas deferens.

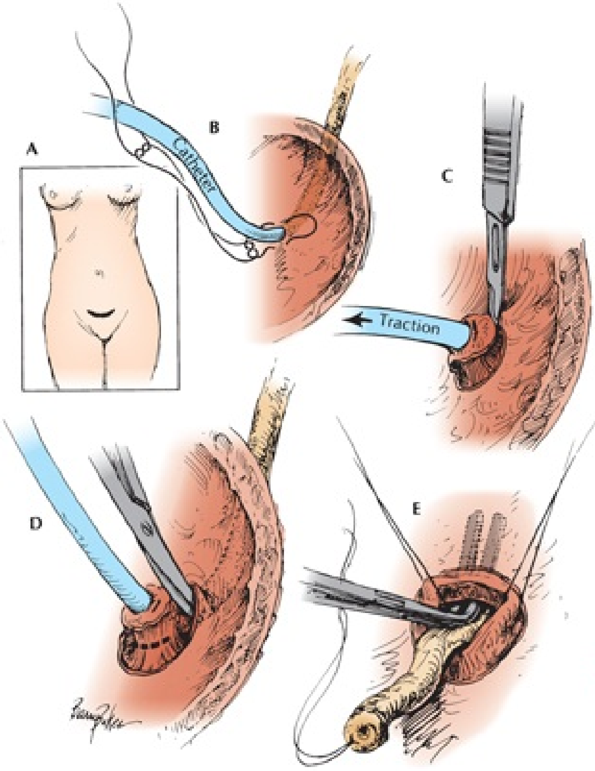

FIGURE 92.6 Intravesical mobilization of ureter. A: Low transverse incision. B: A 3.5Fr or 5.0Fr polyethylene tube and traction suture. C: Incision around meatus with mucosal cuff using long-handled knife. D: Cutting and blunt dissection of muscle of superficial trigone. E: Extravesical mobilization with right-angle clamp and Kittner dissector.

After completion of ureteral mobilization, the surgeon may choose one of several procedures to complete the ureteral reimplantation. The Politano–Leadbetter repair employs a suprahiatal approach (Figs. 92.7 and 92.8). A submucosal tunnel is created from the old hiatus superiorly, long enough to achieve a 5:1 ratio of submucosal tunnel to ureteral diameter. We like to use 135-degree blunt-tipped Metzenbaum scissors to facilitate this maneuver and avoid tearing the bladder mucosa. Once the desired tunnel length is achieved, the new hiatus is developed by making a small incision directly on top of a right-angle clamp. Using a stay suture or the feeding tube, the mobilized ureter is passed from the old hiatus to the new hiatus, care being taken to avoid twisting, kinking, or angulating the ureter as well as avoiding the peritoneum. The mucosa of the old hiatus is repaired with 4-0 chromic catgut. The new meatus is trimmed and spatulated if necessary. The first stitch is critical, anchoring the distal and posterior lip of the ureter with a deep suture of 4-0 or 5-0 chromic catgut to the mucosa and muscular layers of the bladder. The remaining anastomosis is performed with the same suture for a mucosal-to-mucosal approximation, resulting in an everted, patent meatus. Leaving a ureteral stent is at the surgeon's discretion. In general, this is based on the urine output from the reimplanted ureteral orifice; if there is copious drainage, then do not leave a stent, but in the setting of decreased drainage or significant edema at the orifice, a stent is left through a separate stab wound to bring it through the skin. A stent may also be placed if ureteral tapering is required at the time of the reimplant. Cystorrhaphy is done in three layers using running 4-0 chromic catgut for the mucosa, muscularis, and seromuscular layers. This has allowed us to avoid leaving any perivesical drains when the ureters are not stented. A Foley catheter remains in the bladder for 1 or 2 postoperative days.

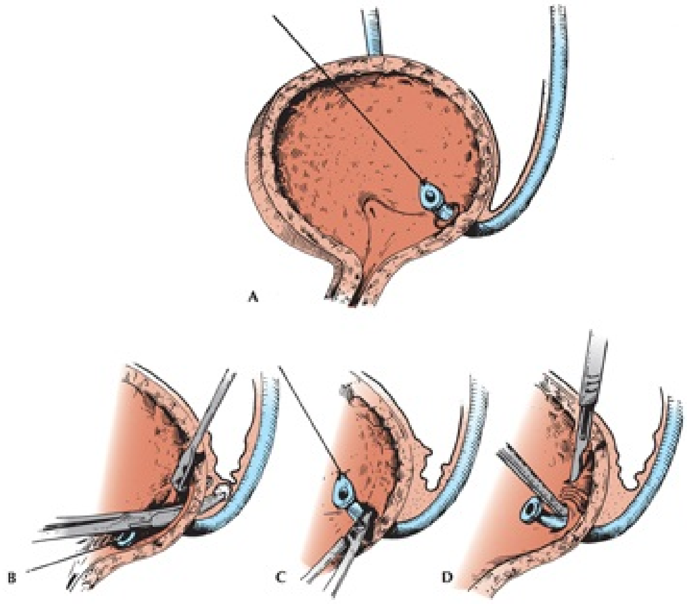

FIGURE 92.7 Politano–Leadbetter repair. A: Mobilization of intravesical ureter. B: Dissection of peritoneum with Kittner dissector. C: Development of submucosal tunnel. D: Creation of the new hiatus.

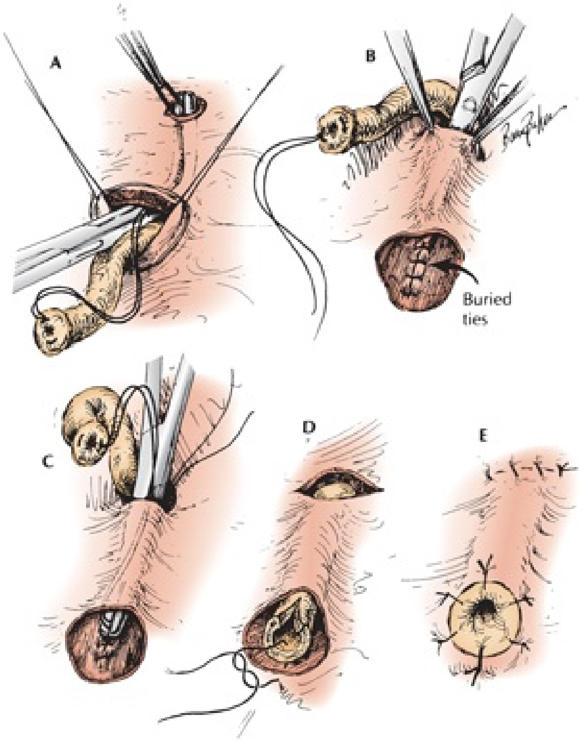

FIGURE 92.8 Politano–Leadbetter repair and details of ureteral reimplant. A: The ureter is brought through the new hiatus, and the old hiatus is closed with interrupted absorbable suture. B: The ureter is brought through the new tunnel (C), spatulated if necessary (D), and sewn in place with interrupted absorbable suture (E).

The Glenn–Anderson procedure (Fig. 92.9) (19), in comparison to the Politano–Leadbetter, is an infrahiatal repair that incorporates a submucosal tunnel advancement toward the bladder neck (Fig. 92.10). It is particularly advantageous when there is sufficient distance between the native ureteral orifice and the bladder neck that an appropriate tunnel length can be obtained. Adequate mobilization of the ureter is paramount to achieve satisfactory success rates. If the tunnel length appears too short on initial inspection, moving the hiatus more superiorly will allow for satisfactory tunnel creation. Advantages of the Glenn–Anderson technique are that the entire procedure is done under direct vision and it creates a relatively straight tunnel with an easily catheterized ureter (as opposed to the course of the Cohen or Politano–Leadbetter reimplant).

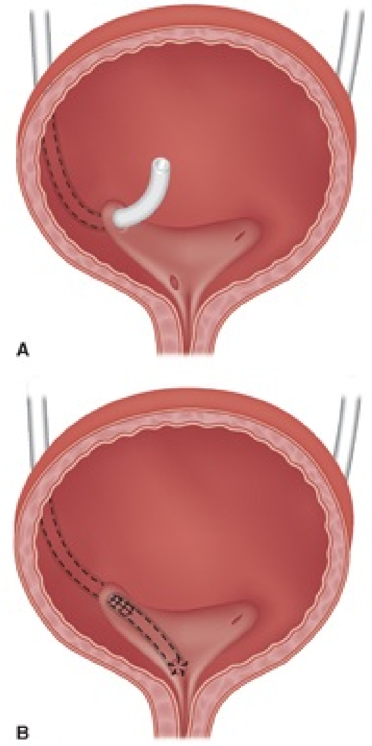

FIGURE 92.9 Glenn-Anderson Repair. Ureter is mobilized from the original meatus through the wall of the bladder (A). Tunnel is advanced caudad in the trajectory of the ureter towards the bladder neck (B). Neo-orifice is sewn in place with interrupted sutures.

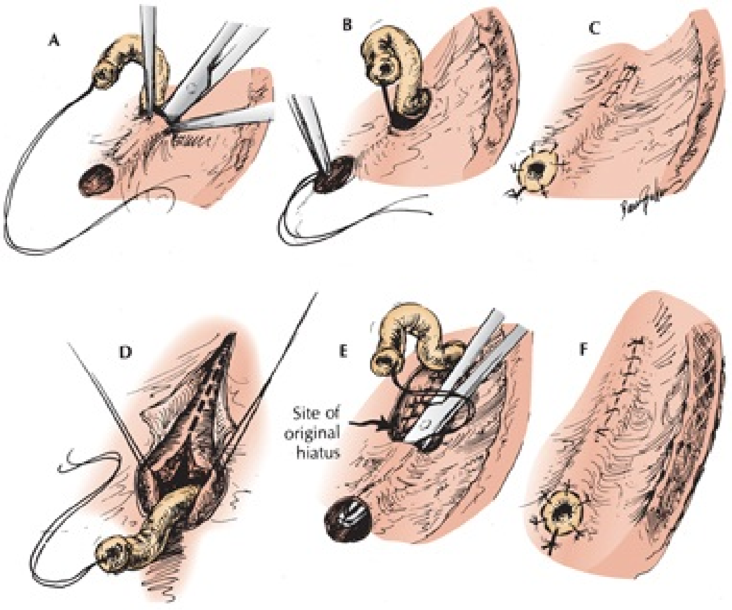

FIGURE 92.10 Glenn–Anderson repair: details of ureteral reimplantation. A: Tunnel made toward bladder neck. The ureter is brought through the tunnel (B) and sewn in place (C). An alternative, similar to the Mathison technique, allows enlargement of hiatus (D) and results in longer repair (E and F).

The cross-trigonal approach (20) is similar to the Glenn–Anderson procedure with the exception that the ureter is transposed across the trigone (Fig. 92.11). This is particularly useful in small-capacity and neurogenic bladders where an appropriately long tunnel is critical to success. The ureteral tunnel created is an extension of the natural course of the ureter; thus, it carries a low risk of ureteral kinking and obstruction. If bilateral reimplant is necessary, it is important to create separate tunnel paths for each ureter. Always remember to close the hiatus with absorbable 4-0 chromic catgut. Leave enough room for a hemostat or right-angle clamp to be interposed between the ureter and the approximated detrusor muscle to avoid obstruction at the hiatus. A potential disadvantage of the Cohen technique is the difficulty of ureteral access postoperatively. These patients may need percutaneous access for any future procedures.

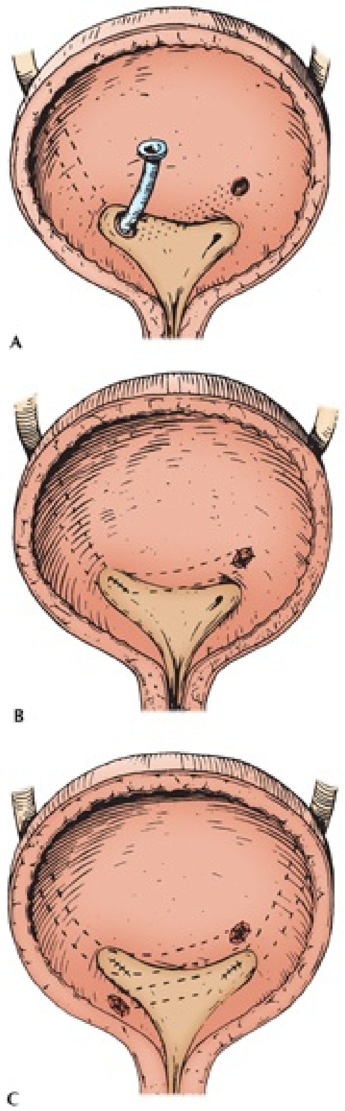

FIGURE 92.11 Cohen technique of ureteral reimplantation. Cross-trigonal tunnel, with the stippled area (A) sewn in place with interrupted sutures (B). C: Bilateral reimplants easily accomplished.

Ureteral Duplication

Determining whether the ureteral duplication is complete or incomplete guides operative considerations. In the absence of a ureterocele, a complete duplication can be approached extravesically or intravesically. The key to intravesical surgery is to mobilize the duplicated ureters as one unit because their blood supply at the bladder level is intertwined within a common sheath (Fig. 92.12). This will avoid devascularization and stricture of the ureter. The technique chosen for reimplant can be achieved with any of the intravesical repairs mentioned. In cases of a complete duplication, an ipsilateral ureteroureterostomy of the refluxing to the nonrefluxing ureter is an attractive alternative. In situations where there is an associated ectopic ureter with a salvageable renal moiety, separate ureteral tunnels should be created or ipsilateral ureteroureterostomy should be performed.

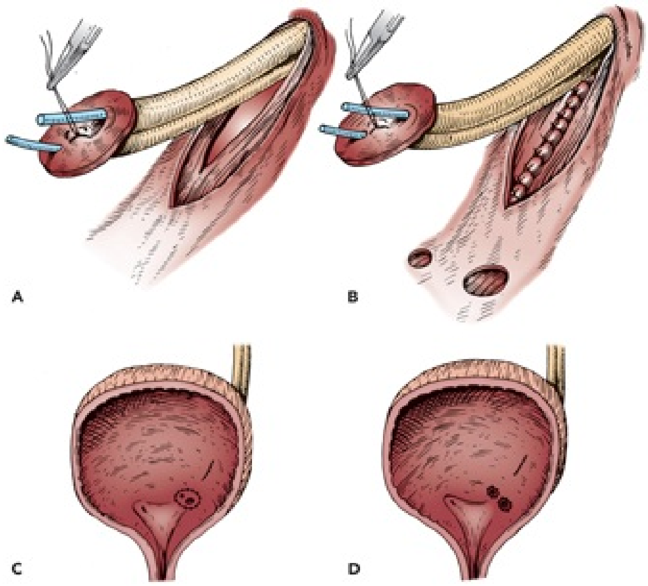

FIGURE 92.12 Reimplantation of both duplex ureters. Reimplantation can be performed with any of the previously described repairs. Care must be taken to mobilize the ureters as a single unit to preserve blood supply (A). Detrusor tunnel should be closed (B) and neoorifice can be performed en-bloc (C) or separately (D), the later of which is particularly suited for an ectopic ureter.

One tip that is useful to aid in freeing up the ureter and also with submucosal dissection for all of the intravesical techniques is the use of 1% lidocaine (Xylocaine) with a 1:100,000 epinephrine solution. This is injected periureterally at the orifice and along the proposed subepithelial tunnel using a 26-gauge needle. This minimizes bleeding and facilitates ureteral dissection in a readily defined plane.

Intra–extravesical Approach

The Paquin technique (Fig. 92.13) (21) is a commonly used repair and has the advantage over the Politano–Leadbetter approach of doing the entire procedure under direct vision, thus avoiding the potential risk of peritoneal injury. The initial approach to the ureter is extravesical, similar to that previously described. When the ureter is mobilized to the level of the detrusor hiatus, a right-angle clamp is placed on the distal ureter, and the distal stump is oversewn after the ureter has been divided using polyglycolic acid suture. Alternatively, the bladder may be opened in the midline and the ureteral orifice circumscribed and mobilized from within the bladder. The ureter should be intubated with a 5Fr or 8Fr feeding tube and secured with a suture prior to mobilization, as described earlier. The ureter is then passed extravesically, taking care to avoid the peritoneum, which should be swept off the posterior lateral bladder wall. If ureteral tailoring is warranted, it is performed at this point. If a longer tunnel is needed and ureteral length is suspect, consider a psoas hitch at this time as well (Fig. 92.14). Place two fingers inside the bladder, bringing it up to the psoas muscle tendon, where it should sit under no tension. Place interrupted figure-of-eight sutures of heavy chromic or polyglycolic acid from the tendon of the psoas to the bladder wall just lateral to where the new ureteral hiatus will be situated. Avoid the genitofemoral nerve superficially and the femoral nerve deep within the psoas during this maneuver. Likewise, the vas deferens in boys and the fallopian tubes in girls must be protected.

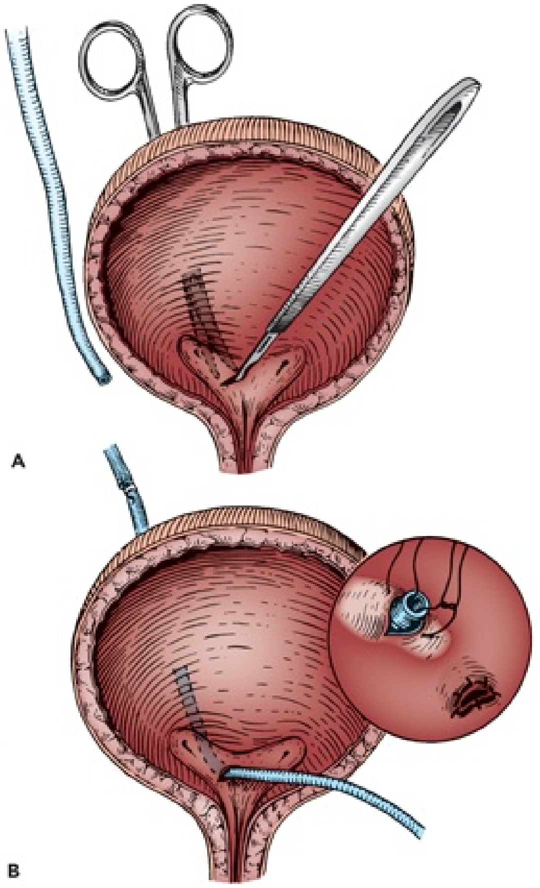

FIGURE 92.13 Paquin Repair. The ureter is mobilized completely, both an intra- and extravesical fashion. A submucosal tunnel is then developed towards the neo-meatus (**A**). The ureter is then advanced through the tunnel and secured within the bladder with interrupted sutures (**B**).

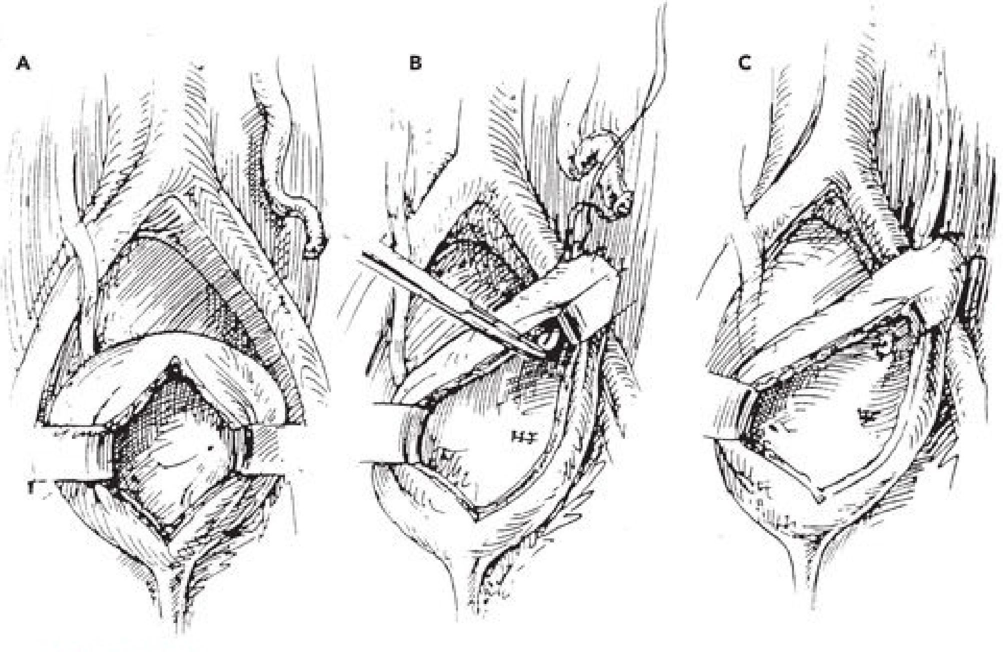

FIGURE 92.14 Bladder mobilized and sutured to psoas over iliac vessels by psoas hitch. **A:** Blunt dissection and exposure of psoas tendon and iliac vessels. **B:** Psoas hitch with interrupted absorbable sutures. **C:** Completed reimplant. Long submucosal tunnel to prevent reflux is shown. (Adapted with permission from Ehrlich RM, Melman A, Skinner DG. The use of the vesicopsoas hitch in urologic surgery. *J Urol* 1978;119:324. Copyright 1978 Elsevier.)

A submucosal tunnel is created as described for the Politano–Leadbetter repair. The ureter is brought through the new hiatus, under the subepithelial tunnel, and secured in its new location. Care is taken to avoid twisting or kinking the ureter as it is brought through the bladder wall. As with all of the intravesical techniques, after the final ureteral anastomosis is complete, a 5Fr feeding tube should easily pass up through the reimplanted ureter to the kidney.

Minimally Invasive Repair

The modern era of minimally invasive surgery has brought forth many new and innovative techniques. These new procedures take advantage of technologic advances and have been designed to decrease patient morbidity while shortening convalescence. The laparoscopic ureteral reimplant has yielded to the robotic-assisted laparoscopic approach, which will be the focus of this discussion. Designed to emulate the Lich–Gregoir repair, this particular repair can be performed transperitoneally or transvesically, the former which is more commonly used and will be discussed in detail. Positioning is either supine or dorsal lithotomy, dependent on patient size. Taller children require the lithotomy position to allow robot docking from the foot of the bed (Fig. 92.15). All pressure points are padded with gel pads, and tape is placed across the chest and midthigh to prevent patient migration during the procedure. Cystoscopy is not required in our opinion, although a Foley catheter is inserted on the sterile field prior to establishing pneumoperitoneum for bladder cycling during the dissection. Pneumoperitoneum in the pediatric population should be obtained via an open technique. A semicircular incision is hidden within the umbilicus, and an 8.5-mm Hassan trocar is inserted as a camera port. Parallel 2-0 polyglycolic sutures can be placed as holding sutures through the fascia to aid with camera port insertion. Direct inspection with the camera should be done to rule out any visceral or vascular injury. Of note, the robotic camera should never be “wiped” on the bowel due to the intensity of the light because this could result in bowel injury. Two additional 5-mm robotic trocars (8-mm trocars can be used in teenagers or larger children) are placed under direction vision on either side of the umbilicus along the midclavicular line (Fig. 92.16A and B). There should be at least 6 cm of separation between ports to allow for full range of movement for the robot. The patient is then placed in steep Trendelenburg to mobilize the abdominal contents cephalad. The initial approach differs based on patient gender because care must be taken to preserve the vas deferens and uterine structures during mobilization (Fig. 92.17A and B). The ureters can typically be visualized through the thin peritoneum, which is incised over the iliac vessels to expose the ureter. The ureter is exposed by gently grasping the adventitia with a Maryland instrument and then tenting it anteriorly with the hook to bluntly dissect the ureter for 5 or 6 cm proximal to the ureterovesical junction (Fig. 92.18A). This dissection will ultimately allow the ureter to lie in the trough without tension. A 0 Prolene suture is placed through the suprapubic region as a hitch stich on the bladder. The needle is straightened and inserted under vision and then passed through the bladder both medial and anterior to the apex of the trajectory of the detrusor trough. Tension is placed on the stitch to pull the bladder anteriorly toward the abdominal wall. This alignment facilitates detrusor dissection. The Maryland is then used to measure the width of the ureter and the length of the detrusorotomy to achieve the desired ratio. Next, the detrusor layer is incised with hook electrocautery and the Maryland dissector, taking caution to avoid violation of the mucosal layer (Fig. 92.18B). Dissection continues for the entire length of the tunnel until the mucosa bulges throughout the incision (Fig. 92.18C). The ureter is placed in the trough, and the detrusor edges are approximated over the ureter with advancement stitches at the apex of the trough (Fig. 92.19A–D). The remaining detrusor defect is closed over the ureter with absorbable suture (5-0 polydioxanone or poliglecaprone) in an interrupted fashion. We recommend closing the fascia at all port sites due to hernia risk. A Foley catheter is left overnight as in the open approach and typically no additional drains are required.

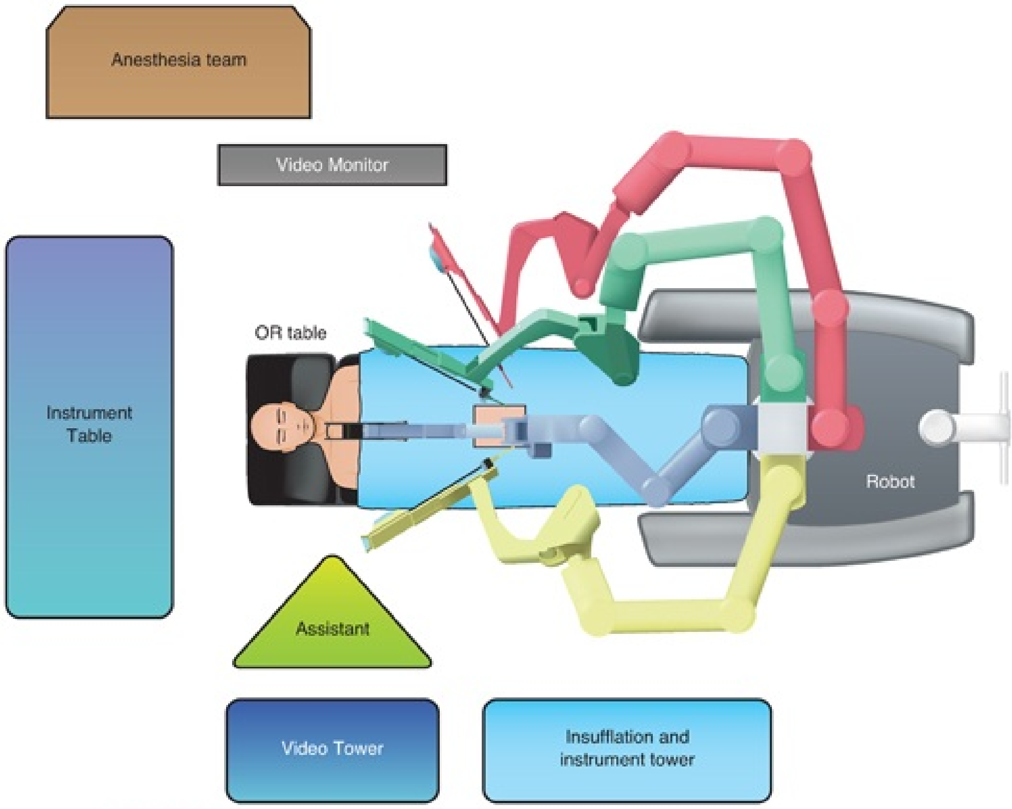

FIGURE 92.15 Layout for robotic procedure. The patient is intubated and the bed is rotated 90 degrees to dock the robot from the foot of the bed. Only one bedside assistant is necessary because no assistant ports are used.

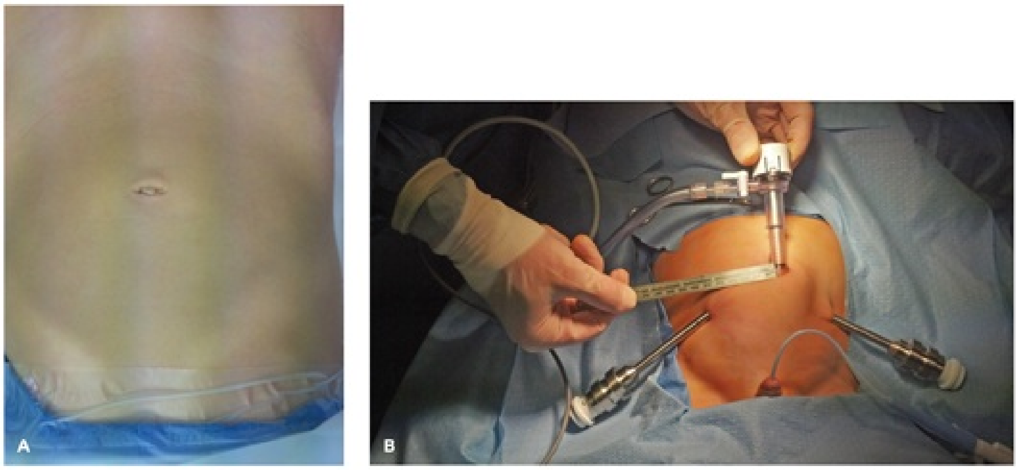

FIGURE 92.16 Port insertion. **A:** An 8.5-mm camera port is inserted within the lower umbilicus (*1*). Two additional robotic ports are placed on either side of the midline within the midclavicular line (*2* and *3*). **B:** Ports should be separated by at least 6 cm and should be approximately 1 cm caudad to the umbilicus. Ports should be adjusted for pubis–umbilicus distance to ensure that there is a safe working distance for the robotic instruments.

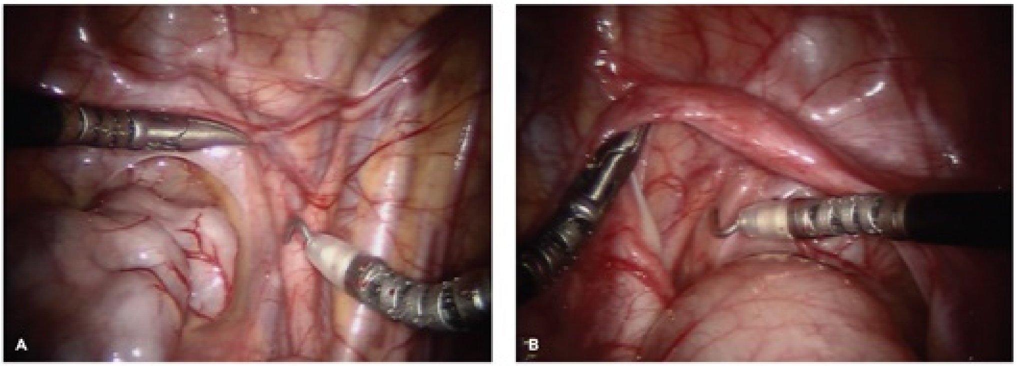

FIGURE 92.17 Exposing the ureter. Peritoneum is incised posterior to the bladder to expose the ureter in its descent to the bladder. The approach differs for males versus females. Care must be taken to avoid damage to the vas deferens in males (**A**), whereas in females, the uterus, uterine artery, and round ligament must be identified during dissection (**B**).

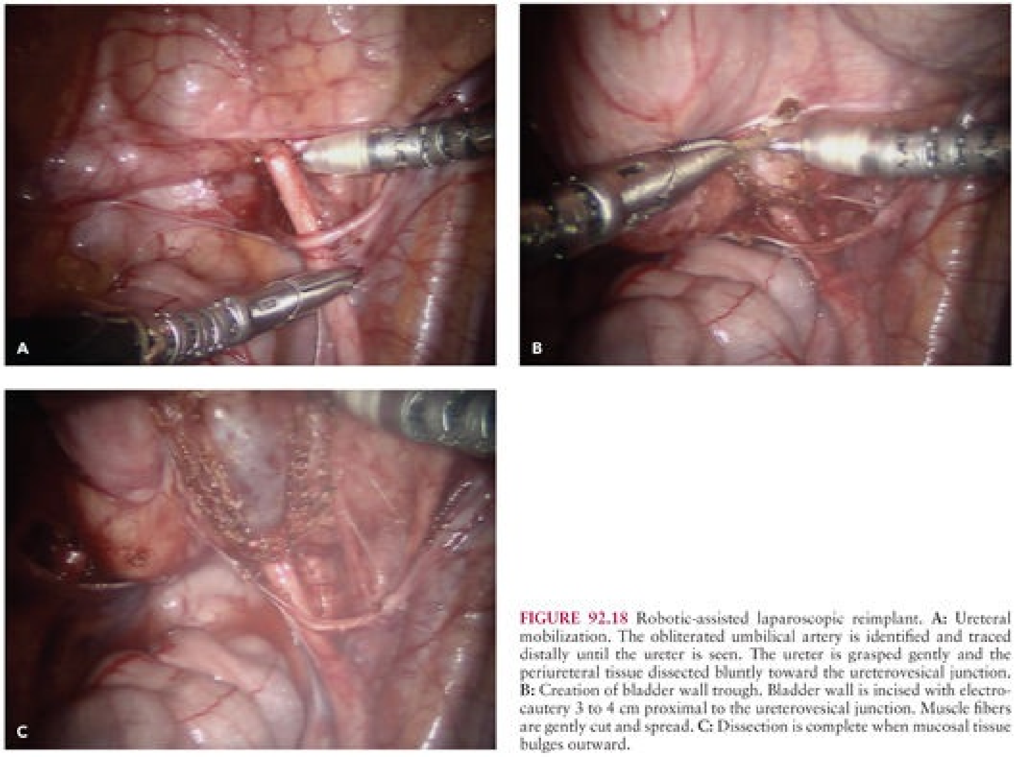

FIGURE 92.18 Robotic-assisted laparoscopic reimplant. A: Ureteral mobilization. The obliterated umbilical artery is identified and traced distally until the ureter is seen. The ureter is grasped gently and the periureteral tissue dissected bluntly toward the ureterovesical junction. B: Creation of bladder wall trough. Bladder wall is incised with electrocautery 3 to 4 cm proximal to the ureterovesical junction. Muscle fibers are gently cut and spread. C: Dissection is complete when mucosal tissue bulges outward.

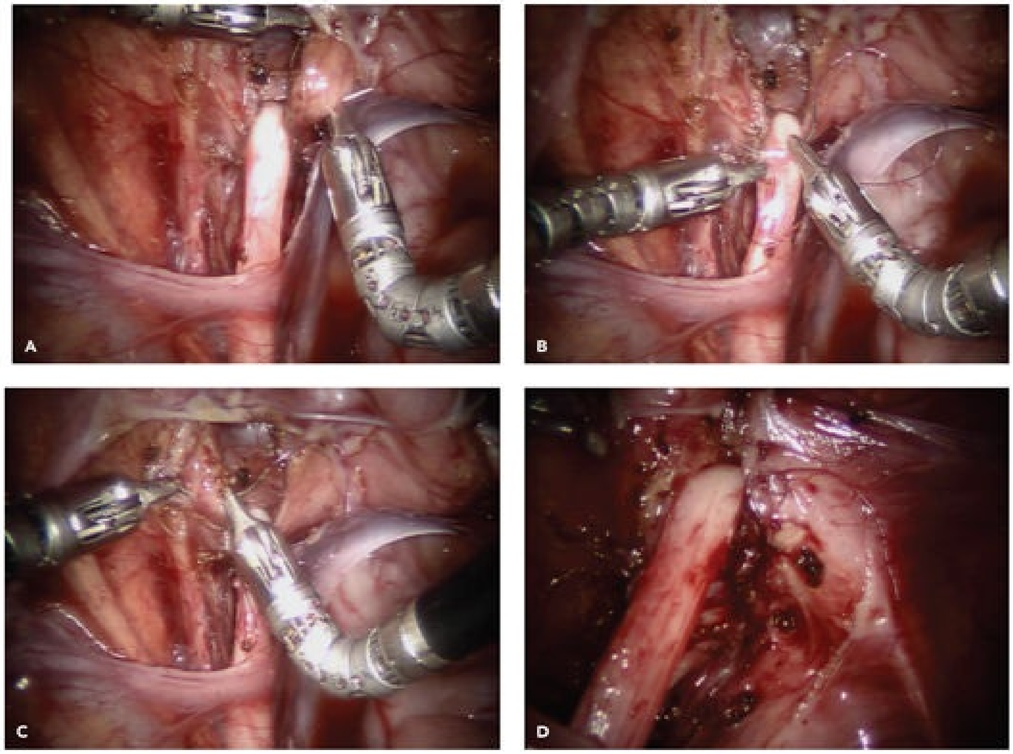

FIGURE 92.19 Detrusorrhaphy is completed with interrupted 5-0 poliglecaprone. A: After placing the ureter in the trough, suturing begins from right to left (out to in) through the detrusor just above the mucosa. The stitch is then passed under the ureter, and the adventitia at the 6 o'clock position is incorporated in the closure (B). C: The detrusor from the contralateral side is then sutured (in to out), and the suture is passed under the ureter to the initial side. D: Completed repair, in this case, a bilateral reimplant. The detrusorrhaphy brings the ureter forward in the repair, limiting visualization of the suture line.

There are few reports in the literature that directly compare the open and robotic reimplant. Those that do have found the robotic approach to result in similar surgical outcomes, albeit with success rates slightly below those for open reimplant. The robotic approach has been found to shorten hospital length of stay and result in decreased narcotic requirement (22,23).

POSTOPERATIVE CARE

The patient stays on prophylactic antibiotics until postoperative US has been performed, usually 4 to 12 weeks postoperatively. In patients with lower grade reflux, no recurrent UTIs, no voiding dysfunction, and a normal US, reflux resolution with confirmatory VCUG study can be avoided. Any patients not meeting these criteria, those with abnormal US, or those with high-grade reflux should undergo a follow-up VCUG or nuclear cystogram at 3 months to assess the surgical result. If reflux is no longer present, we routinely repeat a renal US 1 year later to make sure that anatomically all is well. Should known renal scarring be present, then yearly urinalysis, blood pressure measurements, and periodic US are recommended.

OUTCOMES

Complications

Fortunately, the success rates for open surgery to correct reflux approach 98% for nondilated ureters in patients with normal bladder function. In cases with dilated ureters, significant voiding dysfunction, neuropathic bladder, and secondary reflux such as in prune belly syndrome and posterior urethral valves, the success rates diminish somewhat. Previously unrecognized bladder and bowel dysfunction is the most common cause of postoperative failure and needs to be vigorously addressed preoperatively. The most common complication is persisting reflux on the operative side or contralateral reflux of a previously nonrefluxing ureter. It has been postulated that this is due to a "pop-off" mechanism for ipsilateral reflux and seen mostly in cases of repair of severe reflux or as simply reflux that was missed on initial examination. In most cases, observation with prophylactic antibiotics is the treatment of choice because the vast majority of these patients will have spontaneous resolution of reflux within 1 year. Recurrent reflux that is high-grade suggests technical failure, such as not creating a long enough tunnel or insufficient ureteral mobilization, which frequently requires reoperation.

Ureteral obstruction is fortunately a rare complication of reflux surgery and typically is transient in nature, resulting from postoperative bladder spasms, edema, or intraluminal blood clots. Hence, it is not unusual to see some mild renal or ureteral dilatation in the first few weeks after surgery on sonography. Should problems persist, ureteral stenting or percutaneous nephrostomy will help temporize the situation until resolution occurs spontaneously or surgical reimplantation is performed. Prior to stenting, a Lasix renogram can be obtained to confirm obstruction. Alternatively, a retrograde pyelogram at the time of stenting can be used to evaluate for a stenotic ureterovesical junction or delayed antegrade flow. Our preference is for double-J stent insert to avoid a "dry" anastomosis. Higher grade obstructions usually present with a variety of symptoms such as flank pain, fever, nausea, vomiting, and ileus. These are due to angulation, obstruction at the hiatus, extravasation (of a tapered ureter), or ureteral ischemia with resultant stricturing. Urinary diversion or stenting is paramount in these situations and redo reimplantation required. If the remaining ureter is too short to reimplant in the standard fashion, consider a psoas hitch or a transureteral ureterostomy.

Bladder diverticula are usually the result of a defect in the closure of the muscular hiatus at the original procedure. If the diverticula is wide-mouthed and drains well in the absence of obstruction or reflux, then observation is all that is needed. In the presence of ureteral pathology or poor drainage of the diverticula, surgical correction is necessary.

Robotic reimplant offers the same spectrum of complications as the open approach with the one difference being that the procedure is transperitoneal. Any postoperative leak will result in a significant ileus, which can typically be relieved with continuous bladder drainage. This approach also shares the theoretic risk of bowel and vascular injury, although these are quite rare.

CONCLUSIONS

Surgical management of VUR is highly successful if performed for the right indications and if one adheres to the proper principles of good surgical technique. There are a myriad of corrective techniques available, each with their respective advantages and disadvantages. It is up to the individual surgeon to decide what works best in his or her hands after analyzing the available information on the respective patient.

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CHAPTER 93 ENDOSCOPIC TREATMENT OF VESICOURETERAL REFLUX

ANGELA M. ARLEN AND ANDREW J. KIRSCH

Vesicoureteral reflux (VUR) is the retrograde flow of urine from the bladder to the upper urinary tract and is one of the most common urologic diagnoses affecting children, with an estimated prevalence of 0.4% to 1.8% in the general pediatric population and 30% in those with a history of febrile urinary tract infection (UTI) (1,2). VUR is a risk factor for pyelonephritis, which can lead to renal scarring and subsequent complications such as hypertension, proteinuria, and even chronic kidney disease (3). VUR is one of several modifiable risk factors in the development of UTI. The goal of VUR treatment is to prevent pyelonephritis and preserve renal function. Management options include observation with or without continuous antibiotic prophylaxis and surgical correction via endoscopic, open, or laparoscopic/robotic approaches. Surgical intervention may be necessary in children with persistent reflux, renal scarring, or recurrent febrile UTIs. An individualized risk-based approach that takes into consideration a multitude of demographic, radiographic, and clinical factors should guide management (4).

Endoscopic treatment of VUR is an outpatient procedure associated with decreased morbidity compared to ureteral reimplantation. Endoscopic injection for VUR was introduced in 1981 as an investigational method with the first clinical experience published in 1984 (5,6). Over the past three decades, both injection techniques and bulking agents have significantly improved, which has resulted in higher treatment success rates (7,8). The success rate of outpatient endoscopic treatment of VUR approaches that of open ureteral reimplantation and offers considerable advantages to patients including limited morbidity, fewer complications, and reduced cost. Endoscopic injection has become an increasingly common method of correcting VUR because of its minimal invasiveness and high success rates (9).

DIAGNOSIS

Contrast voiding cystourethrogram (VCUG) has long been a mainstay of VUR diagnosis. Advantages include the ability to grade the severity of reflux based on a standardized international scale, visualization of bladder anatomy, and assessment of the urethra during voiding (10). VUR can also be diagnosed via radionuclide cystography (RNC), which has comparable sensitivity to VCUG (11). VUR grading system conveys clinical significance not only for spontaneous resolution but also for treatment method and outcome (4,12). VCUGs performed with a single cycle of filling and voiding show false negatives up to 15% to 20%; for improved sensitivity, cyclic VCUGs consisting of three voiding cycles are recommended (13,14).

Approximately 30% to 40% of children with febrile UTIs are subsequently diagnosed with VUR. Children who experience recurrent febrile UTIs without evidence of VUR by VCUG may suffer from occult VUR. It is conceivable that despite negative conventional VCUG, occult VUR is clinically significant. One method to diagnose occult VUR is the positional instillation of contrast cystography (PICC). The tip of the cystoscope is positioned at the ureteral orifice and contrast instilled at full flow with a pressure of 80 cm of water. A patient is designated PICC-positive if contrast is seen in the ureter (15). An alternative approach for the diagnosis of occult VUR is hydrodistention of the distal ureter, thus avoiding the use of contrast and ionizing radiation. The degree of hydrodistention has been shown to correlate with the presence of occult reflux. VUR may be incidentally discovered by a VCUG obtained for reasons other than febrile UTIs, such as posterior urethral valves, patent urachus, or suspected bladder rupture. The obligation to diagnose VUR in asymptomatic patients (no history of febrile UTIs, prenatally diagnosed hydronephrosis, sibling screening) has been questioned because the natural history of asymptomatic VUR may be benign and treatment unnecessary.

The “top-down approach” in the management of UTI attempts to distinguish clinically significant from insignificant VUR by evaluating kidneys for pyelonephritis and/or scarring with dimercaptosuccinic acid (DMSA) scans performed within weeks of the onset of acute pyelonephritis. A positive DMSA scan is an indication for VCUG, and consequently, 50% of “unnecessary” VCUGs can be avoided. The 2010 American Urological Association (AUA) Summary Guidelines recommend DMSA imaging in children with primary VUR in whom ultrasound is abnormal or there is greater concern for scarring due to breakthrough UTI, high-grade VUR, or elevated creatinine (16).

INDICATIONS FOR SURGERY

Spontaneous resolution of primary reflux is common secondary to remodeling of the ureterovesical junction (UVJ), elongation of the intravesical ureter, and stabilization of bladder voiding dynamics. Reflux resolution depends on multiple factors including initial grade of reflux, gender, age, voiding dysfunction, presence of renal scarring, and timing of VUR on VCUG (4,12). Management should therefore be individualized and based on patient age, health, VUR grade, clinical course, presence of renal scarring, and parental preference. Surgical intervention may be necessary in children with persistent reflux, renal scarring, or recurrent febrile UTIs.

While open ureteral reimplantation may be a good treatment option after failed injection therapy, endoscopic treatment has also been successfully employed after failed ureteral reimplantation (Table 93.1). Current evidence suggests that either antireflux surgery or continuous antibiotic prophylaxis reduces the incidence of new renal scarring when compared to observation alone (17); however, no study has demonstrated a reduction in the incidence of end-stage renal disease. Valuable goals of VUR treatment are to prevent UTIs, particularly pyelonephritis, to avoid long-term antibiotic prophylaxis, and to reduce the need for distressing VCUGs and radiation exposure. Proponents of the endoscopic approach argue that decreasing the incidence of febrile UTIs is the main goal of therapy. Recurrence, while possible, may occur in the absence of symptoms and be viewed as subclinical, similar to an individual with VUR diagnosed after a sibling screen or for fetal hydronephrosis. Proponents of the open surgical approach comment that ureteral reimplantation provides a permanent cure and is worth the increased morbidity to achieve this goal. In terms of reducing the risk of UTI, endoscopic treatment may achieve this goal as well as or better than open surgery (8,16,18).

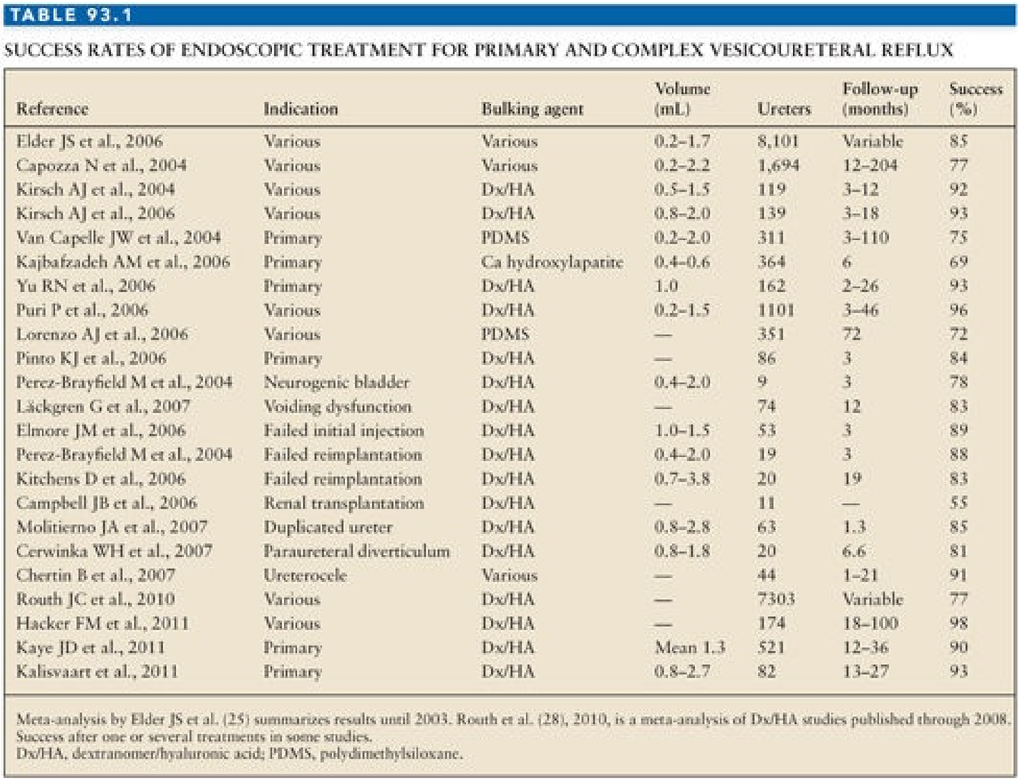

TABLE 93.1

SUCCESS RATES OF ENDOSCOPIC TREATMENT FOR PRIMARY AND COMPLEX VESICOURETERAL REFLUX

Reference	Indication	Bulking agent	Volume (mL)	Ureters	Follow-up (months)	Success (%)
Elder JS et al., 2006	Various	Various	0.2–1.7	8,101	Variable	85
Capozza N et al., 2004	Various	Various	0.2–2.2	1,694	12–204	77
Kirsch AJ et al., 2004	Various	Dx/HA	0.5–1.5	119	3–12	92
Kirsch AJ et al., 2006	Various	Dx/HA	0.8–2.0	139	3–18	93
Van Capelle JW et al., 2004	Primary	PDMS	0.2–2.0	311	3–110	75
Kajbafzadeh AM et al., 2006	Primary	Ca hydroxylapatite	0.4–0.6	364	6	69
Yu RN et al., 2006	Primary	Dx/HA	1.0	162	2–26	93
Puri P et al., 2006	Various	Dx/HA	0.2–1.5	1101	3–46	96
Lorenzo AJ et al., 2006	Various	PDMS	—	351	72	72
Pinto KJ et al., 2006	Primary	Dx/HA	—	86	3	84
Perez-Brayfield M et al., 2004	Neurogenic bladder	Dx/HA	0.4–2.0	9	3	78
Läckgren G et al., 2007	Voiding dysfunction	Dx/HA	—	74	12	83
Elmore JM et al., 2006	Failed initial injection	Dx/HA	1.0–1.5	53	3	89
Perez-Brayfield M et al., 2004	Failed reimplantation	Dx/HA	0.4–2.0	19	3	88
Kitchens D et al., 2006	Failed reimplantation	Dx/HA	0.7–3.8	20	19	83
Campbell JB et al., 2006	Renal transplantation	Dx/HA	—	11	—	55
Molitierno JA et al., 2007	Duplicated ureter	Dx/HA	0.8–2.8	63	1.3	85
Cerwinka WH et al., 2007	Paraureteral diverticulum	Dx/HA	0.8–1.8	20	6.6	81
Chertin B et al., 2007	Ureterocele	Various	—	44	1–21	91
Routh JC et al., 2010	Various	Dx/HA	—	7303	Variable	77
Hacker FM et al., 2011	Various	Dx/HA	—	174	18–100	98
Kaye JD et al., 2011	Primary	Dx/HA	Mean 1.3	521	12–36	90
Kalisvaart et al., 2011	Primary	Dx/HA	0.8–2.7	82	13–27	93

Meta-analysis by Elder JS et al. (25) summarizes results until 2003. Routh et al. (28), 2010, is a meta-analysis of Dx/HA studies published through 2008.
Success after one or several treatments in some studies.
Dx/HA, dextranomer/hyaluronic acid; PDMS, polydimethylsiloxane.

Indications for surgical correction of VUR via open, robot-assisted laparoscopic, or endoscopic approach include moderate- to high-grade reflux (grades III to V), low probability of spontaneous resolution, renal scarring, recurrent pyelonephritis, breakthrough febrile UTI while on continuous antibiotic prophylaxis, and parental preference (19,20). While endoscopic injection has focused on the treatment of primary VUR, it was initially largely avoided for cases of complex VUR (i.e., VUR associated with functional or anatomic abnormalities such as neurogenic bladder or megaureters). In general, endoscopic treatment is emerging at many centers as the first-line surgical treatment modality of choice for VUR, whereas ureteral reimplantation remains reserved for cases of failed injection therapy, significant anatomic abnormalities (i.e., large paraureteral diverticula, ectopic ureters, megaureters), and surgeon or parental preference.

ALTERNATIVE THERAPY

Optimal management remains controversial, and options include observation with or without continuous antibiotic prophylaxis and surgical repair. Families should be thoroughly counseled regarding the various VUR management options and all children should undergo screening for and treatment of bowel/bladder dysfunction. The 2010 AUA guidelines recommend management of any suspected bladder/bowel dysfunction, preferably prior to any surgical intervention (19). Traditionally, most patients diagnosed with VUR were started on antibiotic prophylaxis irrespective of grade. Antibiotic prophylaxis may be continued for several years until VUR resolution or significant grade reduction or if it is deemed clinically insignificant. VUR status has been documented to improve with continuous antibiotic prophylaxis and surveillance (21). The presumed benefits of antibiotic prophylaxis, prevention of pyelonephritis, and avoidance of surgery have been challenged by recent studies demonstrating increased bacterial resistance and failure to protect against UTIs. The *R*andomized *I*ntervention for the management of *V*esico*U*reteral *R*eflux (RIVUR) study is supported by the National Institutes of Health and was designed to address some of the questions that have been raised in the management of VUR including to determine whether antibiotic prophylaxis is beneficial for the prevention of UTIs in children with VUR.

Ureteral reimplantation has a high success rate and prevents VUR by increasing intravesical ureteral length which facilitates compression of the ureter against the backing of detrusor muscle during bladder filling and emptying. Various open reimplantation techniques have been described including both intravesical and extravesical approaches, with success rates typically reported at >95%. Laparoscopic ureteral reimplantation was initially reported in the 1990s. More recently, robotic-assisted approaches have been described, negating some of the longer operative times and technical difficulty associated with pure laparoscopy.

SURGICAL TECHNIQUE

Endoscopic repairs correct VUR by injection of a bulking substance that allows elevation and coaptation of the ureteral orifice and detrusor tunnel (22). Endoscopic correction of VUR using a bulking agent was pioneered by Matouschek (5) in 1981 as an alternative to continuous antibiotic prophylaxis or ureteral reimplantation. O'Donnell and Puri (6) further advanced this concept by performing subureteric injections using Teflon paste coining the term *STING* (subureteric Teflon injection). Modifications of the injection procedure have occurred so that now total ureteral tunnel coaptation is achieved using the hydrodistention implantation technique (double hydrodistention implantation technique [HIT]) (7,23) which involves two intramural injections (proximal and distal). The ideal injectable material should be durable, effective, safe, and should not extrude or migrate. Currently, the only U.S. Food and Drug Administration (FDA)–approved bulking agent is dextranomer hyaluronic acid copolymer (Dx/HA, Deflux). Polyacrylate polyalcohol copolymer (Vantris) has had promising short-term results outside of the United States; however, long-term clinical data is lacking.

Patient Positioning

The patient is placed in the dorsal lithotomy position after induction of general anesthesia. The ability to freely rotate the cystoscope in order to adequately visualize and inject laterally displaced orifices, is important. An offset lens should be used to permit direct passage of the needle in line with ureter without damaging the needle. The bladder should be filled to less than half capacity during injection in order to prevent high tension within the detrusor muscle.

STING (Subureteric Teflon Injection) Technique

When performing the traditional STING procedure, a needle is introduced under the bladder mucosa 2 to 3 mm below the refluxing orifice at the 6 o'clock position and the injection is continued until there is a prominent bulge with the orifice assuming a crescent-like shape (6,22). The injected material augments the tissue below the ureteral orifice, providing a solid support under the refluxing ureteral orifice. This increases the submucosal ureteral length and creates a fixation point whereby the valve mechanism is enhanced preventing retrograde reflux of urine. One concern regarding the STING method is that caudal migration of material, particularly of low injected volume, while resulting in a coapted ureteral orifice initially may result in a failure longer term.

Double Hydrodistention Implantation Technique Method

The endoscopic method currently achieving the highest success rates is the double HIT (Fig. 93.1). Hydrodistention (HD) is performed with the tip of the cystoscope placed at the ureteral orifice; a pressure stream is achieved by placing the irrigation bag approximately 1 meter above the pubic symphysis on full flow. HD is graded according to the distensibility of the orifice (Table 93.2) and allows visualization of the intraluminal injection site as well as assessment of injection progress. Ureteral HD causes the orifice to open before treatment but following proper implantation, the ureter should remain closed with an H0 grade. HD grading correlates with VUR grade, with higher HD grades requiring more injected volume (23). Although HD grade plays a significant role in determining injection volume, surgeon experience, tissue planes, and redo operations also contribute to the volume necessary to achieve an H0 ureter.

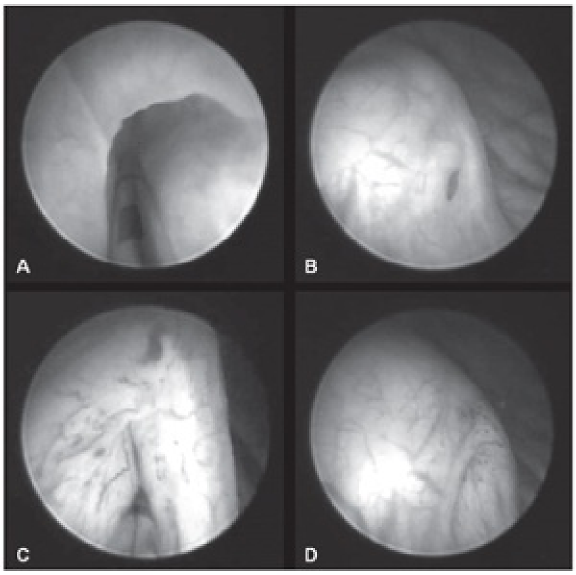

FIGURE 93.1 Endoscopic treatment of vesicoureteral reflux (double HIT technique). A: Proximal intraureteric injection. B: Coapted intramural ureter. C: Distal intraureteric injection. D: Coapted ureteral orifice.

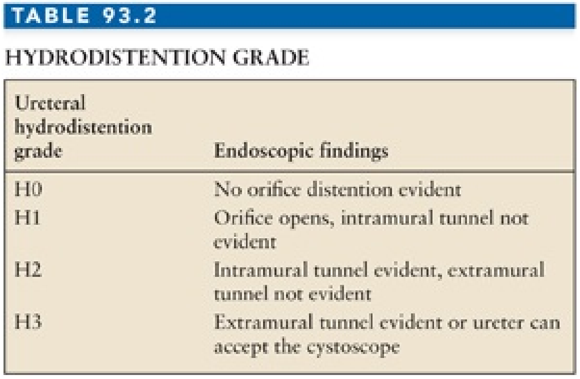

TABLE 93.2

HYDRODISTENTION GRADE

Ureteral hydrodistention grade	Endoscopic findings
H0	No orifice distention evident
H1	Orifice opens, intramural tunnel not evident
H2	Intramural tunnel evident, extramural tunnel not evident
H3	Extramural tunnel evident or ureter can accept the cystoscope

When employing the double HIT methodology, the needle is placed into the ureteral orifice and inserted in the midureteral tunnel at the 6 o’clock position after performing ureteral HD. This differs from the STING technique, where the needle is inserted 2 to 3 mm *below* the refluxing orifice. Bulking agent is injected until a sufficient bulge is produced, which coapts the detrusor tunnel. A second injection at the distal most aspect of the intraureteral tunnel results in coaptation of the orifice. Rarely, if the two intraureteric submucosal injections (double HIT method) fail to coapt the ureter, a classic STING (subureteric Teflon injection) is needed to achieve coaptation (Fig. 93.2). HD is performed following each injection to monitor progress. A retractable injection needle guide (Injekt Needle, Cook Urological) is available that includes a 4-cm filiform needle guide that allows for improved control of injection site and depth (Fig. 93.3).

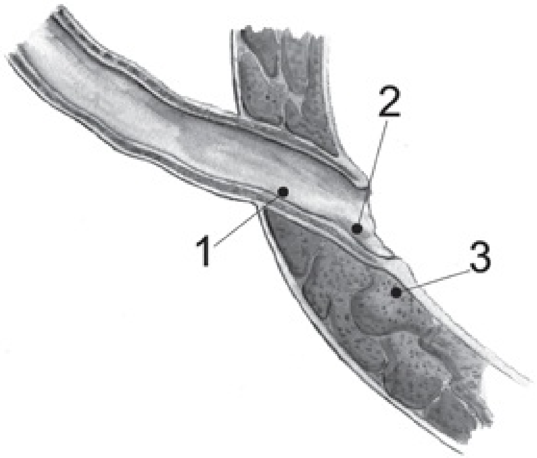

FIGURE 93.2 Needle placement algorithm for the endoscopic treatment of vesicoureteral reflux. The double hydrodistention implantation technique uses sites *1* and *2*; site *3* (subureteric injection of Teflon) is rarely used.

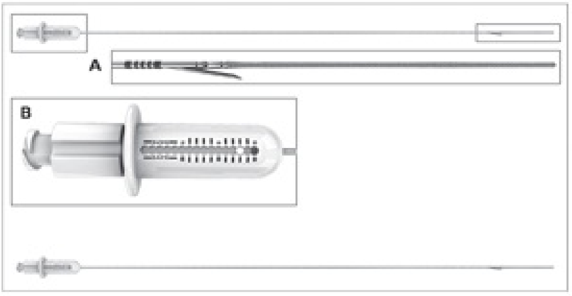

FIGURE 93.3 Retractable injection needle guide (Injekt, Cook Urological, Spencer, Indiana). **A:** Flexible wire is placed into the ureter and the needle is advanced submucosally. **B:** Depth gauge allows needle advancement in 1-mm increments.

In general, all procedures are performed on an outpatient basis and all patients receive preoperative antibiotic prophylaxis, which is continued until clinical follow-up. Patients should be kept on prophylactic antibiotics until appropriate postoperative studies have been obtained, particularly if there is a history of recurrent UTIs preoperatively. Renal ultrasound should be obtained 4 to 6 weeks postoperatively to assess for asymptomatic hydronephrosis. A concomitant bladder sonogram will assess the integrity of the implants. The most recent AUA reflux guidelines (19) also recommend a postoperative VCUG, but there is wide variability in the performance of postoperative imaging dependent on the individual patient and the surgeon's clinical experience and success rate (24).

OUTCOMES

The clinical success of any type of antireflux surgery can be measured both radiographically (absence or downgrading of VUR) and clinically (absence or decrease in frequency of febrile UTIs). In the medical literature, there is considerable variability as to how success is measured; therefore, true surgical outcomes can be difficult to ascertain (24). The outcomes of endoscopic treatment for VUR have been evaluated in several large series (see Table 93.1). Most studies included both primary and complicated cases of VUR; however, interpretation and comparison of these studies are confounded by varying inclusion criteria, different length of follow-up, definition of success, and single versus multiple injections. Nevertheless, the average resolution of VUR following a single endoscopic injection is 83% based on aggregate data, although success rates have ranged from 70% to 95% (20).

Although the STING technique yields lower success rates with higher grades of VUR, the double

HIT method in experienced hands achieves similar outcomes across all VUR grades up to grade V (8). Endoscopic treatment of complicated VUR has been evaluated in smaller series and success rates vary significantly depending on the associated pathology (see Table 93.1). In general, cure rates for complex cases of VUR are lower than for primary VUR. Treatment of VUR associated with neurogenic bladder or voiding dysfunction has been shown to yield acceptable outcomes. Endoscopic injection has also been successfully employed in patients who failed either ureteral reimplantation or initial injection. Injection after failed reimplantation or second injection will be curative in most instances, whereas a third injection has been shown to be far less successful (25). Refluxing ureters of transplanted kidneys in symptomatic patients may be treated endoscopically. Although this approach is curative in only half the cases, it represents an attractive alternative to open surgery in the setting of immune compromise and reduced wound-healing properties. VUR associated with anatomic abnormalities (i.e., duplex ureters, paraureteral diverticula, and ureteroceles), previously thought to be contraindications for endoscopic treatment, have recently shown to be amenable to injection treatment (see Table 93.1).

In addition to proper patient selection, there are a number of technical principles that can help to ensure a successful outcome. Proper injection technique, selection of correct injection site(s), adequate injected volume, and recognizing the end points of the injection are all important components of the injection procedure necessary to follow in order to avert failure. Volume of injection varies depending on the injection method(s). The HD grade of the ureter should directly correlate with the volume used when the double HIT method is employed. After injection, the bladder should be emptied and HD performed to confirm the absence of ureteral distensibility (i.e., H0 ureter). Failures may result from Deflux displacement (implant migration), disruption (mucosal breach), or dissolution (decrease in implant volume).

COMPLICATIONS

In comparison to ureteral reimplantation, endoscopic VUR treatment offers major advantages to patients and parents. The procedure generally lasts <15 minutes and is performed on an outpatient basis. Although cure rates approach those of open ureteral reimplantation, significant complications are rare. Endoscopic treatment entails greater patient convenience, lower morbidity (i.e., pain, abdominal scar), and reduced cost (26).

Complications can be categorized into those that occur in the immediate postoperative period and those that manifest later, even as long as several years from the time of surgical intervention. Early complications typically occur within the first few days following injection and are often transient. Less than 4% of children undergoing endoscopic VUR therapy complain of flank pain or nausea postoperatively and nearly all resolve with analgesics. Ureteral obstruction following endoscopic injection occurs in approximately 0.6% of patients and is frequently associated with voiding dysfunction or with larger ureters when a large volume of bulking agent is injected (19,22). Complete obstruction that requires either placement of ureteral stents or nephrostomy tubes to allow upper tract drainage is rare.

It is not uncommon for patients to develop a febrile UTI after endoscopic injection. This can usually be avoided by checking the urine preoperatively and beginning appropriate antibiotics if indicated. In patients with a symptomatic UTI, surgery should be postponed.

Postoperative reflux may be the result of uncorrected, ipsilateral, or new-onset contralateral reflux. Treatment failure following endoscopic therapy ranges from 7% to 50% and is dependent on the technique, VUR grade, and surgeon experience. Success rates for the double HIT technique approach those following ureteral reimplantation in experienced hands (8). Voiding dysfunction or dysfunctional elimination accounts for the majority of treatment failures. Patients with a previous history of voiding dysfunction must be encouraged to continue their voiding program postoperatively.

Although perhaps not a true surgical complication, the development of contralateral VUR after unilateral endoscopic injection may require continued medical or surgical treatment. This finding has been explained based on either occult reflux or even the possibility that high-grade VUR may be a pop-off mechanism for high bladder pressure, which when corrected may destabilize the contralateral ureter. New contralateral reflux may be prevented by injection of ureters with abnormal HD, that is, grades H2 to H3 (27).

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CHAPTER 94 URETEROCELES

RICHARD N. YU, CHESTER J. KOH, AND DAVID A. DIAMOND

Ureteroceles are congenital cystic dilations of the intravesical submucosal ureter. They are more commonly found in female children and are almost exclusively diagnosed in Caucasians. Approximately 10% of these children have bilateral ureteroceles. Ureteroceles may be orthotopic (contained entirely within the bladder) or ectopic (partially situated at the bladder neck or urethra). An orthotopic ureterocele is typically associated with a single collecting system, whereas an ectopic ureterocele is usually associated with the upper pole moiety of a kidney with complete ureteral duplication.

DIAGNOSIS

Increasingly, ureteroceles are diagnosed by prenatal ultrasonography (Fig. 94.1A and C), which can demonstrate both the intravesical cystic dilation as well as the corresponding hydronephrosis. These patients should undergo a comprehensive postnatal urologic evaluation and be placed on prophylactic antibiotics, which may help to prevent future urinary tract infections (UTIs) (1).

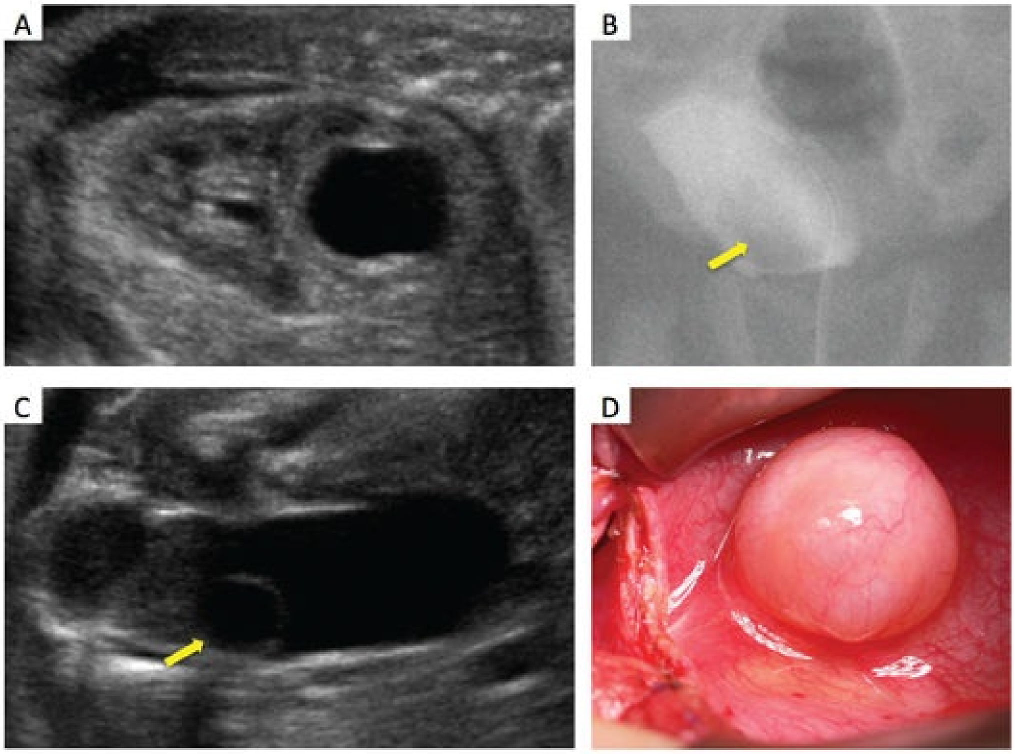

FIGURE 94.1 Ureterocele images. **A:** Fetal ultrasonography demonstrating upper pole hydronephrosis associated with an ectopic ureterocele. The image is oriented with the fetal spine at the top of the image and the head toward the right of the image. **B:** Voiding cystourethrogram with contrast outlining the ureterocele (*yellow arrow*) in a partially filled bladder. **C:** Fetal ultrasonography of the bladder showing a thin-walled ureterocele (*yellow arrow*) within the bladder lumen. **D:** Intraoperative view of a right ectopic ureterocele.

However, for many children, the diagnosis of ureterocele is only made after a UTI or urosepsis. Ureteroceles can also present as a palpable abdominal mass usually representing a hydronephrotic kidney or as a vaginal mass, which represents prolapse of an ectopic ureterocele. Large ureteroceles may even lead to obstruction of the bladder neck or of the contralateral ureteral orifice, which may result in bilateral hydronephrosis.

In general, ultrasonography is the first radiologic study obtained in diagnosing ureteroceles. In addition to the intravesical cystic dilation, ureteroceles are usually seen with duplex collecting systems, with the ureterocele being associated with hydronephrosis of the upper pole moiety.

A voiding cystourethrogram (VCUG) is essential in the evaluation of the patient with a ureterocele because of the high incidence of concomitant ipsilateral and contralateral vesicoureteral reflux. In addition to the reflux, VCUG can demonstrate the size and location of the ureterocele (Fig. 94.1B).

Currently, the dimercaptosuccinic acid (DMSA) renal scan provides the most precise estimate of the differential renal function between each kidney as well as of the associated upper pole contribution to the overall renal function. DMSA scans may even detect lower moiety abnormalities that may not have been demonstrated by ultrasonography (2).

Intravenous urography (IVU) is less commonly used in the modern evaluation of ureteroceles. However, in cases of unusual urinary tract anatomy, IVU, or increasingly magnetic resonance urography (MRU), may be helpful in the delineation of previously undefined anatomy. Severe hydroureteronephrosis associated with a ureterocele may lead to lateral deviation of the upper pole away from the spine.

INDICATIONS FOR SURGERY

The goals of surgical treatment should be the preservation of renal function, elimination of obstruction and reflux, prevention or elimination of infection, and maintenance of urinary continence while minimizing surgical morbidity (3). The main factors to consider in developing an individual treatment plan should be patient age, patient's clinical presentation, ureterocele size and anatomy, presence of reflux and UTI, and function of the involved renal segment.

ALTERNATIVE THERAPY

The anatomy and clinical presentations of children with ureteroceles vary widely. Therefore, each child should have an individualized treatment plan, as no single method of surgical repair is appropriate for all cases. Table 94.1 lists some therapeutic options for patients with ureteroceles.

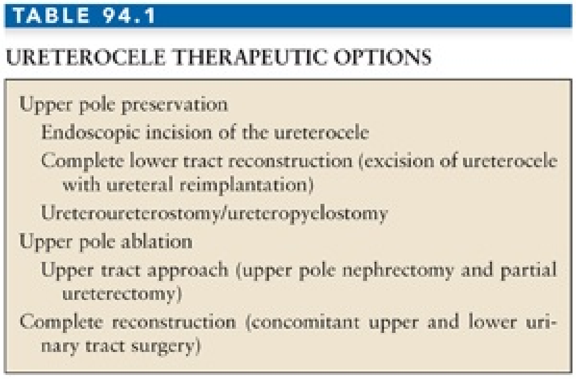

TABLE 94.1

URETEROCELE THERAPEUTIC OPTIONS

- Upper pole preservation
  - Endoscopic incision of the ureterocele
  - Complete lower tract reconstruction (excision of ureterocele with ureteral reimplantation)
  - Ureteroureterostomy/ureteropyelostomy
- Upper pole ablation
  - Upper tract approach (upper pole nephrectomy and partial ureterectomy)
- Complete reconstruction (concomitant upper and lower urinary tract surgery)

SURGICAL TECHNIQUE

Techniques that preserve functional upper pole moieties are listed in the following sections. However, in many instances, the upper pole has little to no contribution to the overall renal function and upper pole ablative techniques, also described in the following sections, may be indicated.

Upper Pole Preservation

Endoscopic Incision of the Ureterocele

The goal of endoscopic incision of ureteroceles is to decompress the ureterocele in a minimally invasive manner while minimizing the risk of postincision vesicoureteral reflux and the need for further urinary tract reconstruction (4). This technique can be used in infants, if infant-sized endoscopic equipment is available, and should be used to drain obstructive urinary systems in any ureterocele patient with urosepsis. Blyth and coauthors (5) recommended the use of a 3Fr Bugbee wire electrode (using the cutting current) to incise the roof of the ureterocele through its full thickness near its base and proximal to the bladder neck. A new unobstructed intravesical ureteral orifice will be created, and the roof of the collapsed ureterocele can act as a flap-valve mechanism to prevent reflux. Although the Bugbee electrode has been a widely used instrument for ureterocele puncture, it has limitations, primarily that following initial decompression enlargement of the puncture site is difficult. Therefore, we prefer to use the pediatric resectoscope and the right-angle hook electrode with the cutting current, which allows one to make a clean transverse incision and enlarge it by placing the hook into the original incision and withdrawing under vision (Fig. 94.2). Magnification with the use of video projection helps improve the accuracy of the incision. Making the incision as distal and as close to the bladder neck as possible should reduce the risk of postoperative reflux into the corresponding ureter. The adequacy of the incision can be confirmed by the presence of a jet of urine from the ureterocele or by visualization of the urothelium inside the ureterocele. The major advantage of the endoscopic incision is that it can be done on an outpatient basis without the need for hospitalization. Other energy sources, such as a laser, have also been described as an alternative method of endoscopic incision (6).

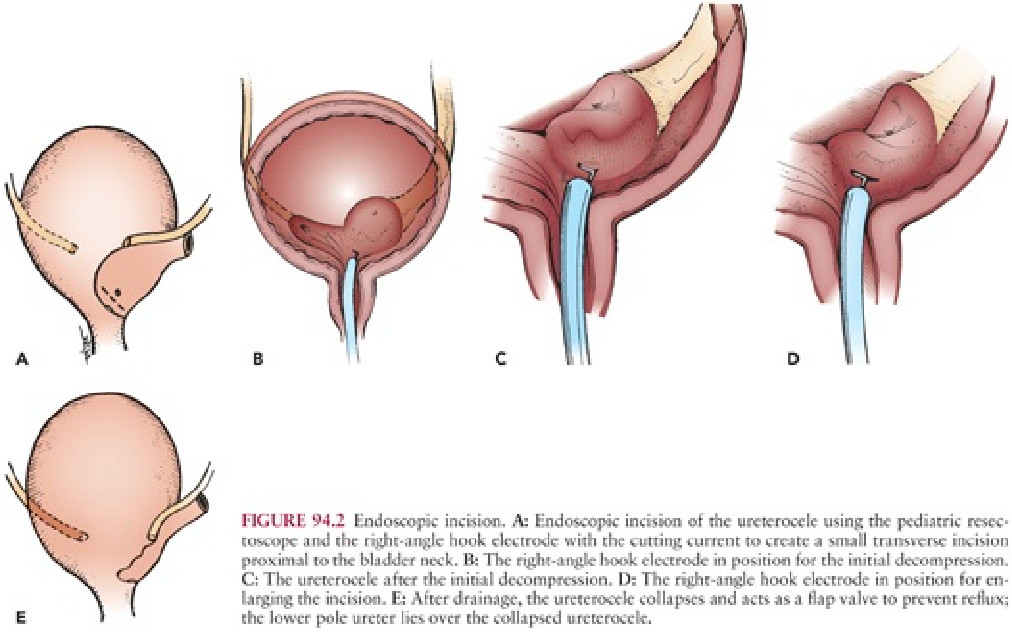

FIGURE 94.2 Endoscopic incision. **A:** Endoscopic incision of the ureterocele using the pediatric resectoscope and the right-angle hook electrode with the cutting current to create a small transverse incision proximal to the bladder neck. **B:** The right-angle hook electrode in position for the initial decompression. **C:** The ureterocele after the initial decompression. **D:** The right-angle hook electrode in position for enlarging the incision. **E:** After drainage, the ureterocele collapses and acts as a flap valve to prevent reflux; the lower pole ureter lies over the collapsed ureterocele.

Complete Lower Tract Reconstruction (Excision of Ureterocele with Ureteral Reimplantation)

For excision of the ureterocele and common sheath reimplantation of upper and lower pole ureters, a Pfannenstiel incision is made and the bladder is opened (Fig. 94.3). The lower pole and contralateral ureters are intubated with 5Fr feeding tubes and multiple circumferential stay sutures are placed. A circumferential incision is made around the perimeter of the ureterocele with electrocautery and the wall of the ureterocele and its associated upper pole ureter are dissected away from the thinned posterior muscular wall of the bladder, incorporating the lower pole ureter in the dissection. All attempts should be made to avoid injury to the sphincteric mechanisms at the bladder neck during the distal dissection of the ureterocele. The upper and lower pole ureters are dissected as a common sheath to avoid injury to the blood supply of both ureters. After excising the distal ureterocele, the dilated upper pole ureter often requires tapering. The thin posterior bladder wall is repaired by imbrication of adjacent muscle with running 3-0 absorbable sutures to provide sufficient muscle backing for the reimplanted ureters. An unoperated portion of the bladder floor is selected and the ureters are reimplanted as a common sheath into a generous ureteral tunnel.

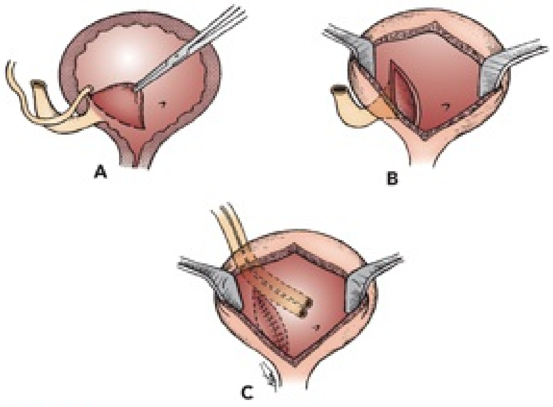

FIGURE 94.3 Complete lower tract reconstruction. **A:** After the bladder is opened, multiple circumferential stay sutures are placed around the ureterocele to assist with the excision. **B:** All ureters should be intubated with 5Fr feeding tubes for identification of the ureters during the dissection. **C:** After excising the ureterocele, the posterior bladder wall is repaired with running 3-0 absorbable sutures and the ureters are reimplanted into a generous tunnel.

Ureteroureterostomy/Ureteropyelostomy

In upper urinary tract anastomotic techniques, the dissection of the upper tracts should be kept to a minimum, and mobilization should be directed toward the upper pole ureter, so that distortion of the adjacent lower pole ureter can be avoided. Because the upper pole ureter is usually larger than the lower pole ureter, generous spatulation of the recipient ureter during ureteroureterostomy may be necessary for an optimal end-to-side anastomosis. Furthermore, a feeding tube should be passed distally into the ureterocele to decompress it. This procedure can be performed using a laparoscopic or robotic approach with improved morbidity in older children and adolescents.

Upper Pole Ablation

Upper Tract Approach (Upper Pole Nephrectomy and Partial Ureterectomy)

In many cases, the upper pole associated with the ureterocele has minimal or no contribution to the overall renal function. The upper tract approach (upper pole nephrectomy and partial ureterectomy) should lead to the relief of obstruction, prevention of recurrent infection, and resolution of the reflux that is present in about half of these patients. This approach should result in the decompression of the ureterocele, hopefully with resolution of the ipsilateral lower pole reflux, because the trigone will be returned to a more normal configuration. This usually eliminates the need for lower tract reconstruction with a potentially difficult bladder neck and urethral dissection (3).

For the upper pole heminephrectomy, we suggest the use of the flank or laparoscopic or robotic approach, which offers superior access to the upper pole vessels. With either approach, care should be taken to avoid excessive traction on the kidney to avoid damage to the viable lower pole. In many cases, the upper pole resembles a dysplastic nubbin, and early division of the upper pole ureter with upward traction on the proximal portion of the transected ureter usually helps in the definition and manipulation of the upper pole (Fig. 94.4). After the upper pole vessels are sequentially ligated, demarcation of the upper pole parenchyma should become apparent. We recommend the use of a no. 15 blade or electrocautery around the upper pole parenchyma, which usually results in a wedge-shaped defect. During the dissection of the upper pole parenchyma, the plane of dissection should remain as close to the upper pole ureter to avoid injury to the vascular supply of the lower pole ureter. After upper pole nephrectomy, the wedge-shaped defect is closed with interrupted 3-0 chromic sutures in a vertical mattress fashion to achieve effective hemostasis. Interposition of perinephric fat or a cellulose-based hemostatic polymer (Surgicel) with a hemostatic matrix may be useful for larger defects.

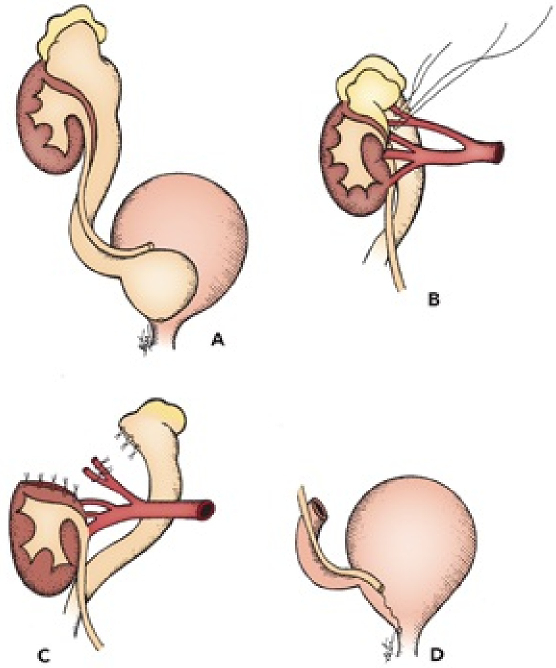

FIGURE 94.4 Upper pole partial nephrectomy and partial ureterectomy. **A:** This procedure is commonly used for a duplex system with a nonfunctioning upper pole and minimal or absent ipsilateral reflux. **B:** The upper pole ureter is transected early after a stay suture has been placed proximally. Upward traction on the proximal portion of the transected ureter assists in the manipulation of the upper pole during the partial nephrectomy. **C:** After removal of the upper pole, the wedge-shaped kidney defect is repaired with 3-0 chromic sutures in a vertical mattress fashion. **D:** This approach should result in the decompression of the ureterocele, with the return of the trigone to a more normal configuration.

Complete Reconstruction

In certain instances, complete reconstruction may be indicated where both an upper tract repair and a lower tract reconstruction are performed via separate incisions in a single stage. These situations include the presence of high-grade reflux into the ipsilateral lower pole ureter or the presence of lower pole reflux associated with a large, everting ureterocele and a nonfunctioning upper pole segment. Depending on the amount of upper tract function, either an upper pole nephrectomy with partial ureterectomy or a ureteropyelostomy (as described earlier) is performed for the upper tract repair. Lower tract reconstruction is also performed, which involves excision of the ureterocele with reimplantation of the ureters as a common sheath, as previously described.

OUTCOMES

Complications

Excision of the ureterocele with ureteral reimplantation achieves the goal of upper tract drainage. However, the disadvantage of this approach is the morbidity associated with bladder surgery, including hematuria, bladder spasms, and catheter drainage. Extensive distal dissection also carries the risk of bladder neck and sphincteric injury, which may jeopardize urinary continence (7).

Results

Endoscopic incision of the ureterocele may be the only surgical procedure required for many patients. For infants, endoscopic incision may be used as a temporizing measure that achieves early decompression. Secondary surgery, if necessary, can be performed electively when the child is older. If the ureterocele is orthotopic, one can expect high rates of decompression and low rates of de novo reflux and the need for secondary procedures (8). On the other hand, ectopic ureteroceles are associated with a high rate of secondary surgery and a significant incidence of postoperative reflux after endoscopic incision. Therefore, patients with ectopic ureteroceles may be best served by more definitive reconstruction, even those younger than 1 year of age (9).

The upper tract approach, which includes upper pole nephrectomy and partial ureterectomy, is usually reserved for the patient with an upper pole that provides little or no contribution to the overall renal function and mild or absent ipsilateral reflux. This approach has the advantage of avoiding the lower tract complications noted earlier.

For patients who are at significant risk for requiring a second procedure with some of the approaches detailed earlier, such as those patients with large, ectopic ureteroceles or high-grade ipsilateral reflux, complete upper and lower tract reconstruction in a single stage has the advantage of expediency (10).

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CHAPTER 95 ■ URACHAL ANOMALIES AND RELATED UMBILICAL DISORDERS

LESLIE T. MCQUISTON AND ANTHONY A. CALDAMONE

During bladder development, the urogenital sinus is initially contiguous with the allantois. When the lumen of the allantoic duct becomes obliterated, the urachus remains, connecting the bladder to the umbilicus (Fig. 95.1A and B). It continues to elongate as the fetus grows. The urachus is a muscular tube, with a length ranging from 3 to 10 cm and a diameter of approximately 8 to 10 mm that extends from the dome of the bladder to the umbilicus. It has three distinct tissue layers: (a) an epithelial-lined lumen with cuboidal or transitional epithelium, (b) an intermediate connective tissue layer, and (c) an outer smooth muscle layer. In the adults, the urachus lies between two layers of umbilicovesical fascia along with the umbilical ligaments and the remnants of the obliterated umbilical arteries. This fascial investment tends to contain the spread of urachal disease between the peritoneum and transversalis fascia (Fig. 95.1C).

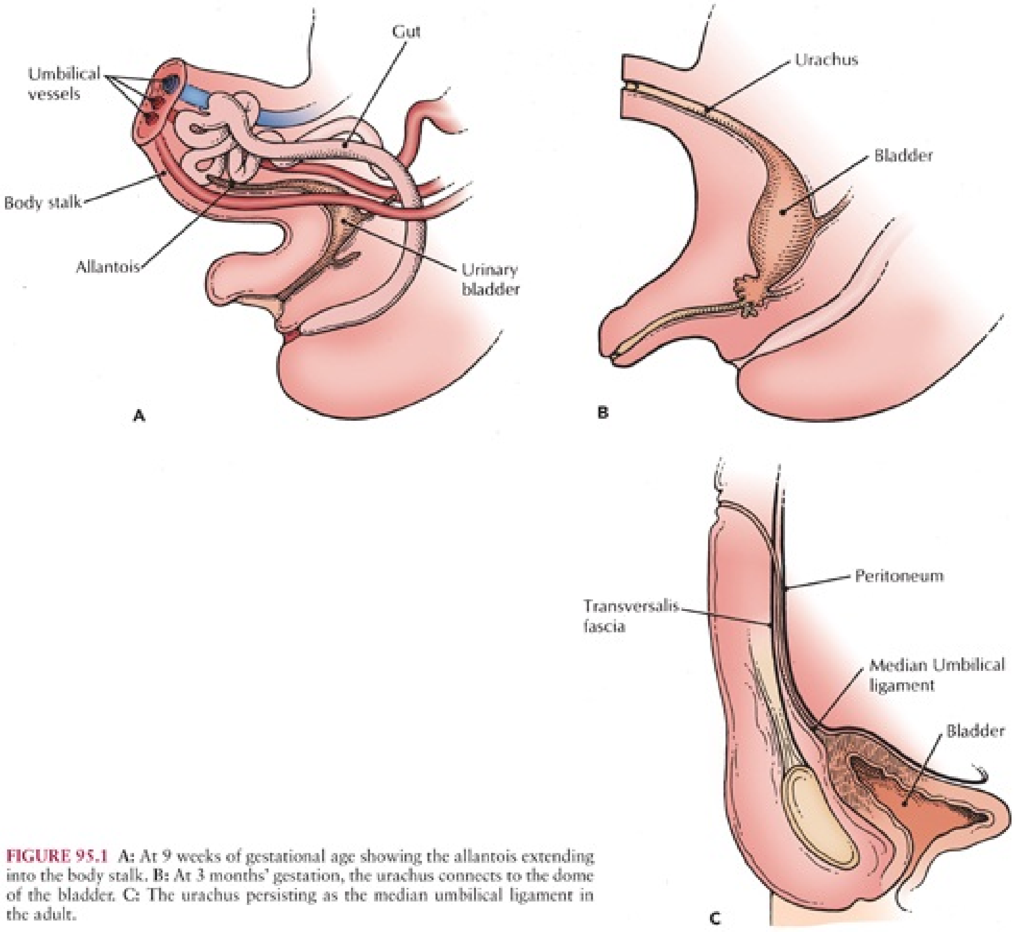

FIGURE 95.1 A: At 9 weeks of gestational age showing the allantois extending into the body stalk. B: At 3 months' gestation, the urachus connects to the dome of the bladder. C: The urachus persisting as the median umbilical ligament in the adult.

The urachus normally closes or involutes at approximately 32 weeks' gestation, and urachal anomalies in general represent an abnormality in the involution process. The anomalies that can result are characterized as patent urachus, urachal cyst, urachal sinus, and urachal diverticulum (Fig. 95.2) (1). Of these anomalies, urachal cysts (45%) and sinuses (37%) are the most commonly identified (2). With the level of detailed imaging available, incidental atretic, cordlike umbilical remnants are also commonly reported.

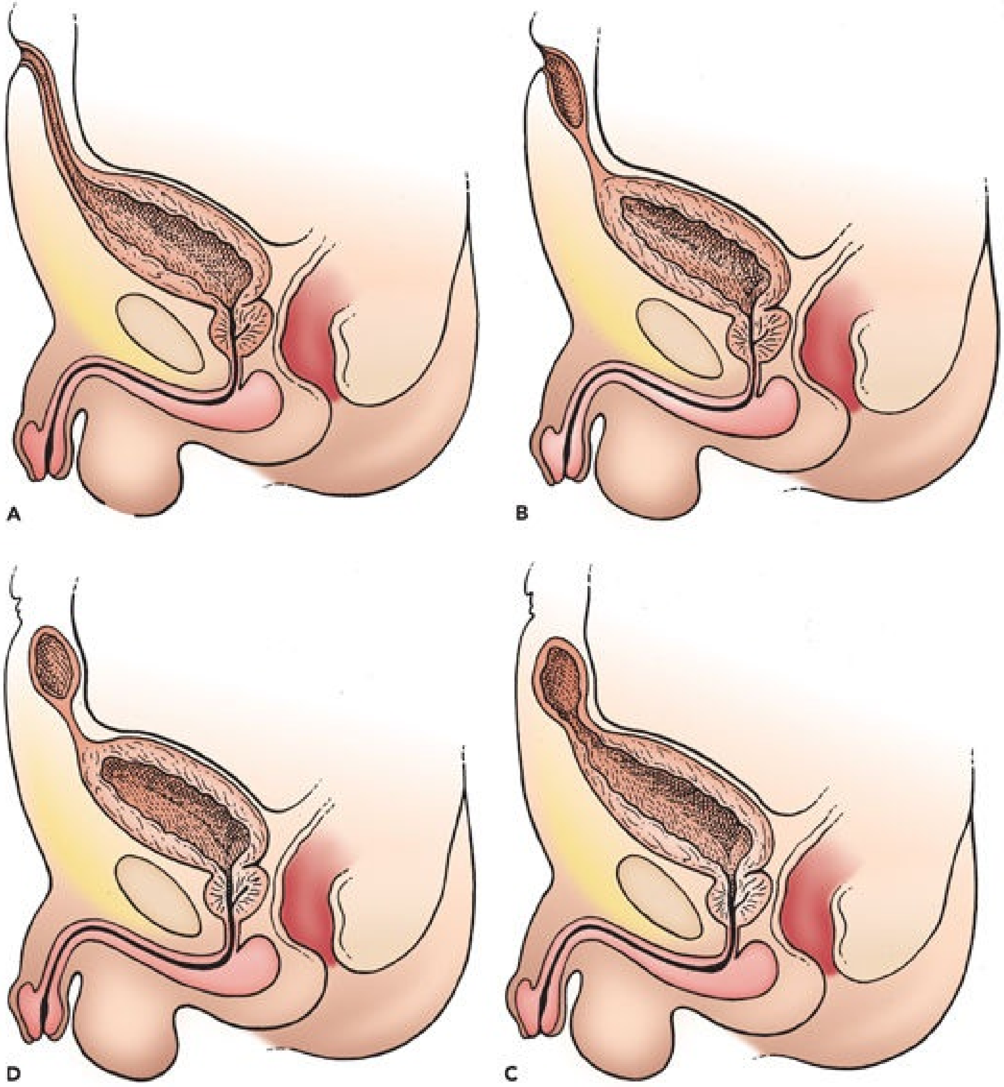

FIGURE 95.2 The four types of abnormalities involving the urachus. **A:** Complete patency to the umbilicus. **B:** A blind-ending urachal sinus open at the umbilicus but not complete to the bladder. **C:** A urachal cyst without communication to either the umbilicus or the bladder. **D:** Simple diverticulum from the dome of the bladder.

DIAGNOSIS

In general, the diagnosis of urachal anomalies requires clinical suspicion and a thorough physical examination. Further evaluation in patients with periumbilical drainage should include a sinogram, and those with a periumbilical mass should undergo ultrasonographic imaging. A voiding cystourethrogram may be required in selected patients (2,3).

Complete failure of the urachal lumen to close results in an open connection between the bladder and the umbilicus. Patients present with umbilical leakage of urine and often a protruding tissue mass (Fig. 95.3). The leakage may be more obvious during times of increased intra-abdominal pressure such as crying, coughing, or straining. The fluid may be analyzed for urea and creatinine to confirm its urinary quality. Two factors thought to contribute to a persistent patent urachus are bladder outlet obstruction and failure of the bladder to descend into the pelvis (4,5). With regard to bladder outlet obstruction, distal urinary obstruction is thought not to be the only causative factor because normally, the urachus closes developmentally before the urethra becomes tubularized (6). In addition, only 14% of patients with patent urachus demonstrate bladder outlet obstruction clinically, and it is uncommon for a patent urachus to be associated with posterior urethral valves. Alternatively, it can be seen with urethral atresia, as in prune belly syndrome. The diagnosis may be confirmed with a sonogram, although a voiding cystourethrogram may be more useful because it may rule out bladder outlet obstruction concurrently. Alternatively, methylene blue or indigo carmine may be instilled in either the bladder or the umbilical opening and detected in the umbilicus or bladder, respectively. The differential diagnosis for patent urachus includes patent omphalomesenteric duct, urachal sinus, omphalitis, granulation of a healing umbilical stump or umbilical granuloma, and infected umbilical vessel. An umbilical granuloma may be associated with a small amount of serous drainage and may appear similar to a patent urachus. It may have a smooth or irregular surface and may appear pedunculated. Normal imaging studies in these patients suggest the diagnosis of umbilical granuloma.

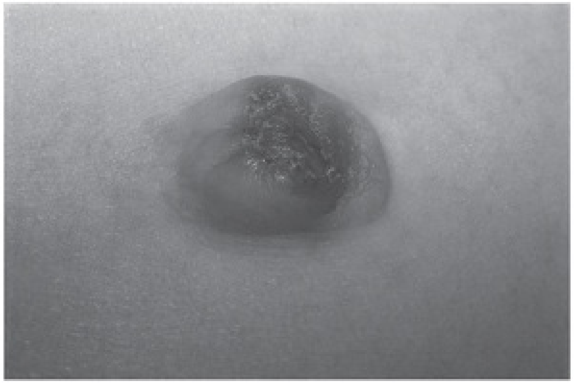

FIGURE 95.3 Patent urachus.

Segmental or incomplete closure of the urachal lumen may result in the formation of a urachal cyst (Fig. 95.4). The cyst usually forms in the proximal or lower third of the urachal remnant near the bladder (7). Usually, the cyst is lined with transitional epithelium and filled with serous fluid, but mucinous contents have been described. In general, urachal cysts are small and asymptomatic. Symptoms such as pain, erythema with localized swelling, and tenderness below the umbilicus may occur with infection and may be accompanied by chills, fever, irritative voiding symptoms, hematuria, and pyuria. Alternatively, symptoms may arise as the result of mass effect due to a large urachal cyst. These patients present with a sensation of abdominal fullness or pain, a mass, or irritative voiding symptoms due to compression of the bladder. Diagnosis is most easily confirmed by ultrasound or computerized tomography (CT).

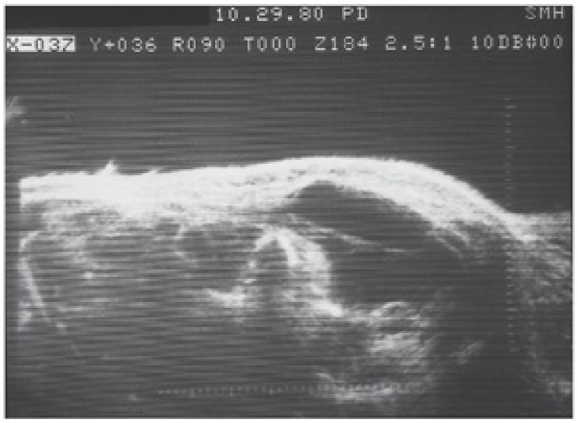

FIGURE 95.4 Abdominal ultrasound that demonstrates an infected urachal cyst.

Incomplete closure of the urachus may also result in a urachal sinus. This may be the result of a urachal cyst that extended either to the bladder or to the skin for drainage. Some urachal sinuses may alternate and at first drain at the umbilicus and then later into the bladder. Presenting symptoms may include periumbilical erythema and tenderness with intermittent drainage, umbilical irritation or granulation tissue, or symptoms of urinary tract infection. Clinical suspicion of a urachal sinus may be confirmed by a sinogram or ultrasound. A cystogram may show an irregular area at the dome of the bladder. Cystoscopy may demonstrate an inflamed area at the dome that may extrude purulent drainage.

A urachal diverticulum results from failure of closure of the urachus adjacent to the bladder, leaving a wide-mouth diverticulum at the dome of the bladder. The urachal diverticulum may or may not be associated with bladder outlet obstruction, as has been often reported in patients with prune belly syndrome. In general, aside from treatment for any coexisting bladder outlet obstruction, the urachal diverticulum requires no specific management, as it usually drains well.

Omphalomesenteric disorders may be confused with urachal anomalies. The omphalomesenteric duct is a fetal structure that connects the yolk sac and the gut. Incomplete closure of this tubular structure may lead to a patent omphalomesenteric duct, an omphalomesenteric sinus, or an omphalomesenteric cyst. A patent duct may be characterized by the drainage of intestinal fluid or fecal material. A sinogram should demonstrate a connection to the gastrointestinal tract.

Malignant lesions of the urachus are rare; however, the cancer risk does increase with advancing adult age (8). The most common sign of urachal cancer is hematuria. Patients may also present with a suprapubic mass, abdominal pain, irritative voiding symptoms, or mucus in the urine. The diagnosis may be made by identification of a filling defect at the dome of the bladder with calcifications on intravenous urogram or cystogram, CT, and cystoscopy with transurethral biopsy. Adenocarcinoma remains the most common malignancy (9); however, sarcoma, transitional cell carcinoma, leiomyoma, and teratoma have been reported as case reports.

INDICATIONS FOR SURGERY

Surgical management has been central to the treatment of urachal anomalies with the exception of infants younger than 6 months of age, in whom the anomalies may resolve spontaneously, and the wide-mouth diverticulum, which in general requires no treatment (10). However, recent studies have shown that even in older children, there is a subset of patients in whom spontaneous resolutions occurs, leaving observation as a viable treatment option (11). In the patient with a persistently patent urachus beyond 6 months of age, surgical excision should be considered because of the risk of recurrent infections; stone formation; and persistent umbilical drainage, excoriation, and pain.

Urachal cysts that are symptomatic due to size or infection also merit surgical treatment. Incidentally discovered small, asymptomatic urachal cysts may be excised at the time of discovery or watched for the development of symptoms or progressive enlargement. With infected cysts, initial antibiotic therapy with possible drainage followed by delayed excision may be required. Similarly, in the case of the urachal sinus, initial treatment should focus on the eradication of any infection before excision is considered. Nonspecific atretic umbilical remnants do not require excision.

With regard to omphalomesenteric ductal anomalies, referral to a pediatric surgeon is recommended for treatment. Small umbilical granulomas may be treated with silver nitrate application, whereas larger or refractory granulomas may require surgical excision. Treatment of urachal malignancy follows the principles of treatment for any malignancy of the bladder and is discussed elsewhere in this book.

SURGICAL TECHNIQUE

For the patent urachus, urachal cyst, alternating urachal sinus, or urachal diverticulum requiring correction, the patient is placed in a supine position. If possible, a small catheter, guide wire, or probe is placed through the patent urachus (Fig. 95.5). If nothing will pass, the tract may be stained with methylene blue for later identification. A Foley catheter should be placed in the bladder and the bladder distended with sterile saline to bring the anterior bladder wall up to the abdominal wall and, in doing so, push the peritoneum cephalad.

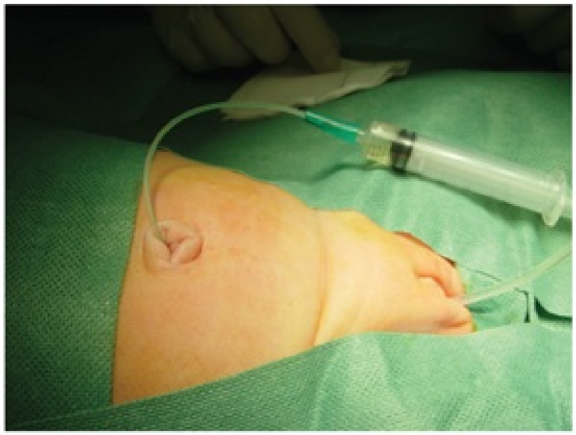

FIGURE 95.5 A catheter in place in a patent urachus.

The urachus may be approached via a vertical midline incision or a transverse infraumbilical incision one-half to two-thirds the distance from the symphysis pubis to the umbilicus (Fig. 95.6). Although the transverse infraumbilical incision will result in excellent exposure, alternatively, a vertical midline incision along the course of the urachus may be more direct and can allow for extension to the umbilicus in a cosmetic fashion, should this be required because of difficulty in procuring the umbilical end of the urachus or for any additional necessary procedures. The rectus fascia is opened and the dome of the bladder is identified. The urachus is identified and isolated. Once the proximal portion of the urachus is delineated, it is resected along with a small cuff of bladder to prevent a residual diverticulum. The bladder is then closed in two layers (Fig. 95.7). Dissection then proceeds toward the umbilicus. The operation is facilitated by identifying the proper plane of dissection between the peritoneum posterior to the urachus and the posterior rectus fascia, which is anterior to the urachus. In this same plane will lie the obliterated umbilical arteries, which may be ligated proximally on the bladder wall or distally at the umbilicus.

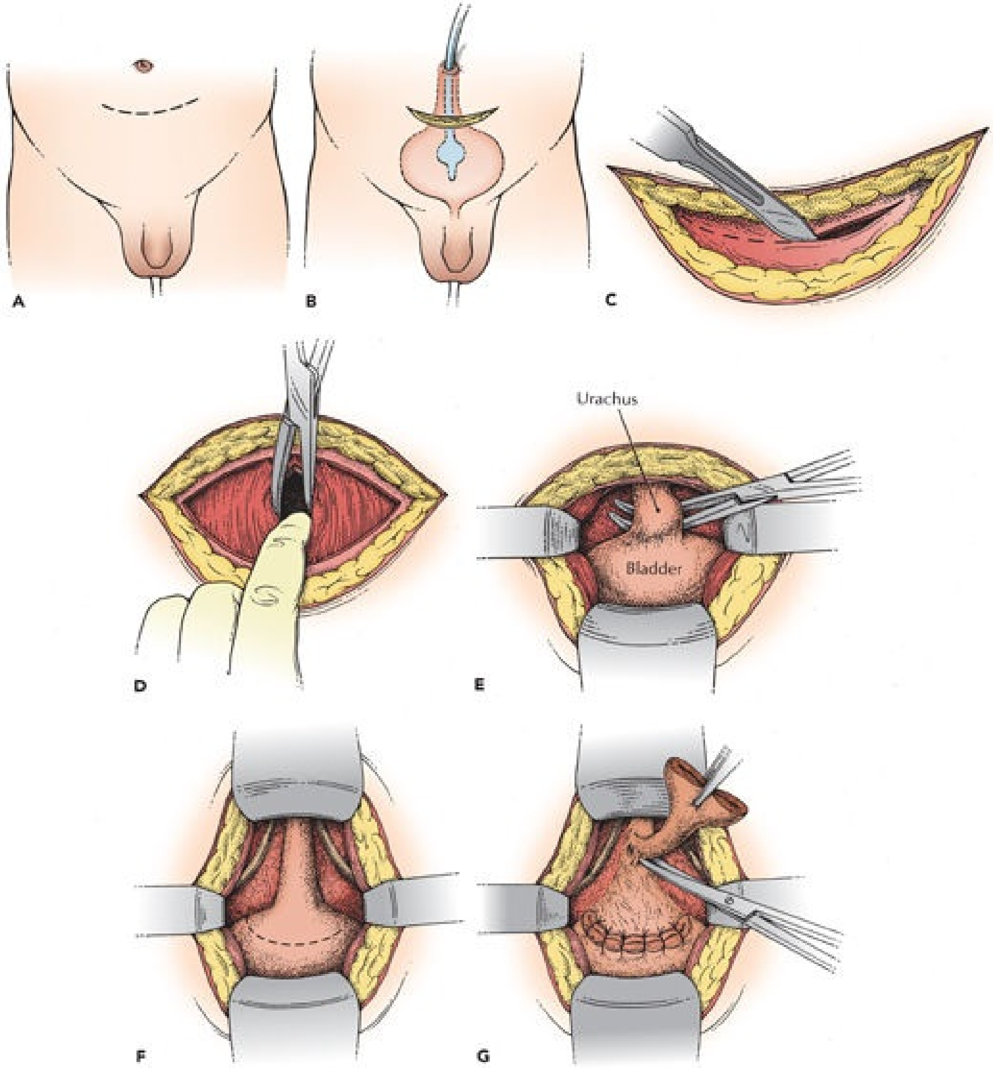

FIGURE 95.6 **A and B:** Typical transverse infraumbilical approach to the urachus. The catheter through the urachus can aid in identification of a patency. **C and D:** The fascia is divided transversely and the rectus muscle is parted in the midline, remaining preperitoneal. **E:** The urachus or urachal remnant can be separated from the peritoneum and identified in its proximal and distal extent. **F and G:** The urachus is resected with a cuff of bladder and the bladder closed in a watertight fashion. The urachus is removed completely out to the umbilicus if necessary.

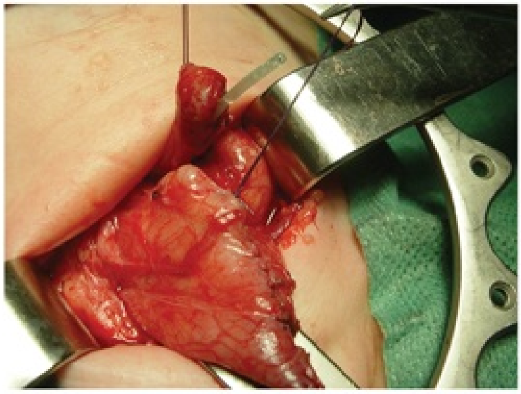

FIGURE 95.7 Intraoperative view after separation of the patent urachus (with catheter) after closure of the bladder.

Infected urachal remnant structures, such as urachal cyst or sinus, may present a more challenging dissection. In fact, it is sometimes advisable to drain a large infected urachal cyst initially percutaneously and allow a period for antibiotic therapy to reduce the local inflammation. Smaller infected urachal cysts or sinuses, however, can be managed safely as a single procedure. With these infected remnants, it may be impossible to dissect the urachus away from contiguous structures. For instance, a larger portion of the bladder may need to be removed with the infected urachal cyst. Similarly, one may find it impossible to separate the infected cyst or sinus from the underlying peritoneum. One should be extremely careful in identifying adherent loops of bowel that may have been involved in the inflammatory process and could easily be injured.

Once the urachus is completely dissected distally, it is excised or ligated at its obliterated point. The goal is to remove all urachal tissue and leave the umbilicus intact. If an umbilical hernia is present, it may be corrected concurrently. A catheter may be left in the bladder and a drain in the prevesical space postoperatively at the surgeon's discretion.

For the urachal sinus draining at the umbilicus, dissection is begun by circumscribing the sinus, again with the goal of preserving as much of the umbilicus as possible. The obliterated umbilical arteries are ligated as they are encountered. The tract is dissected to its termination and excised, and the area is drained because the sinus tract is usually infected.

An alternative to open surgical treatment is laparoscopic treatment. Laparoscopic treatment, including robotic treatment, has been reported in both children and adults with excellent visualization and access to the urachal remnant (Fig. 95.8) (12,13). Port placement may vary by surgeon preference; however, in general, the first port is placed using the open Hasson technique in the midline halfway between the umbilicus and the xiphoid process, and two additional ports are placed under direct vision on each anterior axillary line just above the umbilicus, creating an angle of approximately 45 degrees between the working ports. The procedure then follows the principles as outlined previously for open surgery.

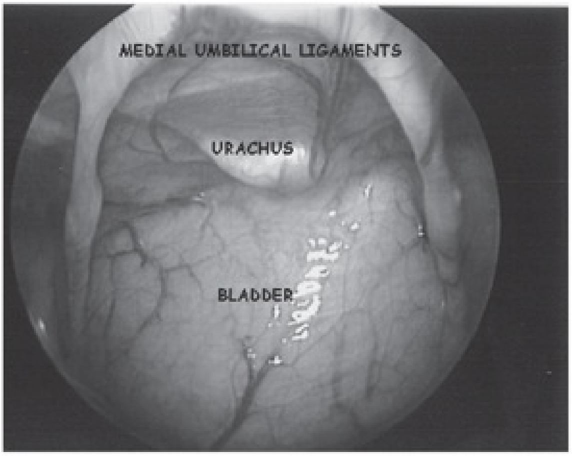

FIGURE 95.8 Typical view of the bladder and urachus during laparoscopy with a 30-degree telescope, showing the urachus, bladder, and medial umbilical ligaments.

OUTCOMES

Complications

Postoperative complications include persistent urinary drainage, which can be managed by prolonged bladder catheter drainage, and infection, which is generally superficial and responds well to antibiotic therapy. With laparoscopic procedures, the reported complications are most often port-related, and therefore, open Hasson technique for initial port placement is recommended.

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CHAPTER 96 VESICAL NECK RECONSTRUCTION

JOHN C. POPE IV AND JOHN H. MAKARI

Prior to toilet training, the functions of the lower urinary tract include storage of urine at low pressure and good emptying. The result is protection of the upper tract and avoidance of urinary tract infection. Adequate outflow resistance is not necessary during that time but is eventually critical to achieve urinary continence. Congenital anomalies resulting in inadequate outflow resistance, and thus failure to achieve urinary continence, can in general be divided into two groups based on pathophysiology. In the first group, there is an anatomic or developmental abnormality where the bladder outlet is malformed and incapable of providing adequate resistance. This group would include patients with bladder exstrophy, bilateral single ectopic ureters, persistent cloaca, and rarely an extensive ureterocele. In the second, more common, group involving neurogenic dysfunction, the outlet is normally developed from an anatomic standpoint, but abnormal neurologic control results in inadequate function.

Diagnosis

When urinary continence is not achieved in children, the critical evaluation is video urodynamic study of the bladder and outlet. Parameters that need to be evaluated include sphincteric function, outflow resistance, detrusor function, and bladder compliance.

Monitoring of external urinary sphincter activity is helpful during studies of storage and emptying. Perineal surface electrodes are most widely used to evaluate the activity; however, in children with neurogenic dysfunction who tolerate placement, a concentric needle electrode or dual electrodes placed through a 25-gauge needle increases accuracy.

The functional length and pressure of the external sphincter is important and can be measured with urethral pressure profilometry. This measurement is technically challenging in a small child and there are no standard nomograms for urethral pressure profilometry to use in pediatric patients. Continuous monitoring of the urethral pressure during filling in the area of maximum resistance may demonstrate an etiology for incontinence. Some surgeons also use leak point pressure to evaluate outflow resistance during passive filling and performance of Valsalva maneuvers. Simultaneous fluoroscopic observation is advantageous.

Detrusor function should be evaluated by the cystometrogram, synergistic relaxation of the external sphincter on electromyography, urinary flow rate, and measurement of postvoid residual urine. Bladder compliance should also be evaluated with the detrusor pressure measured as the bladder is filled with warm saline or contrast (37°C) at a rate equal to or less than 10% of estimated or known bladder capacity. Such filling minimizes irritation of the bladder that may artifactually increase bladder pressure. Other artifacts that affect the measurement of compliance, such as urinary infections or low urethral resistance, should be eliminated to obtain the best results.

Before reconstructive surgery on the bladder is considered, the status of the patient's upper urinary tract should also be evaluated. Standard evaluation includes renal ultrasonography and serum electrolytes, including creatinine. If significant hydronephrosis is present, renography should be obtained to rule out obstruction. Vesicoureteral reflux should be sought on voiding cystourethrography, often at the time of video urodynamic evaluation. Any upper tract obstruction or reflux should be corrected at the time of lower urinary tract reconstruction.

Unfortunately, no test ensures that a patient will be able to void spontaneously and empty well after outlet reconstruction with or without bladder augmentation. All patients must be prepared to perform clean intermittent catheterization before considering reconstruction. The native urethra should, therefore, be examined for the ease and discomfort of catheterization.

INDICATIONS FOR SURGERY

If urinary continence is not achieved at an appropriate age in patients with congenital anomalies, and the patient has failed behavioral regimens such as timed voiding, all medical regimens, and other conservative therapies (e.g., intermittent catheterizations), then surgical intervention should be considered. The International Children's Continence Society recommends that surgical treatment should be tailored to the individual patient, with consideration being given to patient age, history, urodynamic findings, and coexisting disabilities (1). It is critical to ensure that the bladder is a compliant storage reservoir prior to any reconstructive procedure on the lower urinary tract. Increasing outflow resistance in the presence of inadequate bladder capacity would put the patient at significant risk for upper tract deterioration and febrile urinary tract infection. Determining the commitment of the patient and family to achieve a good result with reconstructive surgery, including a willingness to perform intermittent catheterization if necessary, is critical.

SURGICAL OPTIONS

In few areas of reconstructive urology, there are as many choices to consider as for bladder neck repair and as little consensus as to which repair is appropriate for a given patient or setting. One reason for the variety of choices is the wide range of patients and problems for which the procedures are used. In some cases, the procedure to increase outflow resistance may logically be chosen based on particular patient considerations, but the experience and confidence of the surgeon with a given technique also may play a significant role in the choice.

Conceptually, techniques to increase outflow resistance may be considered as one of two general types. The first set of repairs is used to improve the function of the native outlet, while the second set is designed to repair the anatomy and functionally alter the outlet. Several procedures that may provide benefit and are occasionally used include urethral suspensions, injection of bulking agents, artificial sphincters, and obliteration of the bladder neck.

One of the first bladder neck repairs to function in such a manner was the urethral suspension described by Marshall–Marchetti–Krantz, which has since been modified by numerous surgeons. While these procedures have been successful in treating stress urinary incontinence among neurologically normal females, they have had minimal effect and are rarely indicated for pediatric patients with congenital anatomic anomalies of the outlet or neurogenic dysfunction.

Recently, transurethral injection of bulking agents has been tried to improve the function of the existing outlet. Initially, the use of polytetrafluoroethylene and later bovine collagen were reported. More recently, the availability of dextranomer/hyaluronic acid copolymer has renewed interest in injection therapy for increasing bladder outlet resistance and for correction of sphincteric incontinence. Injection therapy is relatively simple, avoids any incision, but has met with limited results for significant outlet anomalies (2). Further, the durability of this approach is a concern, as declining rates of dryness and/or improvement are observed even years after treatment (3). Injection therapy may, however, be useful after primary repairs in patients who have some persistent incontinence (3–5).

The most definitive procedure to improve the function of the outlet as it exists is placement of an artificial urinary sphincter. This group of procedures would seem appropriate for patients with a normal or near-normal outlet from an anatomic standpoint and to have little role for patients with significant anatomic anomalies such as bladder exstrophy or bilateral single ectopic ureters. Even with improved durability in newer models, the average life span of an artificial urinary sphincter is 8 years. Therefore, when placed in a pediatric setting, future revision surgery is inevitable (6).

The ultimate procedure to increase outlet resistance is division and closure of the bladder neck. Effective closure requires extensive mobilization of the bladder and bladder neck away from the urethra with interposition of omentum. It must be accompanied by construction of a continent abdominal wall stoma for bladder catheterization and effectively moves the reconstruction into the realm of continent urinary diversion. Division of the bladder neck has in general been reserved for complex patients who have failed multiple prior procedures to effectively increase outflow resistance; however, it may be performed in select patients as primary definitive management. Extremely high success rates have been reported for both primary or secondary management when the above principles are followed (7).

SURGICAL TECHNIQUE

Fascial Sling for Bladder Neck Suspension

In adults, fascial slings may be performed transvaginally, and a small patch of fascia is secured with suspension sutures. In pediatric patients with congenital anomalies, fascial slings have in general been placed from above, often at the time of bladder augmentation. Before placement, the pelvic floor is cleared of overlying fatty tissue and a 2-cm incision made through the endopelvic fascia on either side of the bladder neck and proximal urethra (Fig. 96.1A). This area may be identified by palpation of a transurethral catheter and balloon seated at the bladder neck. Using blunt dissection, a plane is developed between the bladder neck and vagina in girls or rectum in boys (Fig. 96.1B). This plane may at times be more easily developed from the cul-de-sac by dissecting behind the bladder and ureters from above. With a difficult dissection, it may be useful to open the bladder, in particular if bladder augmentation is planned.

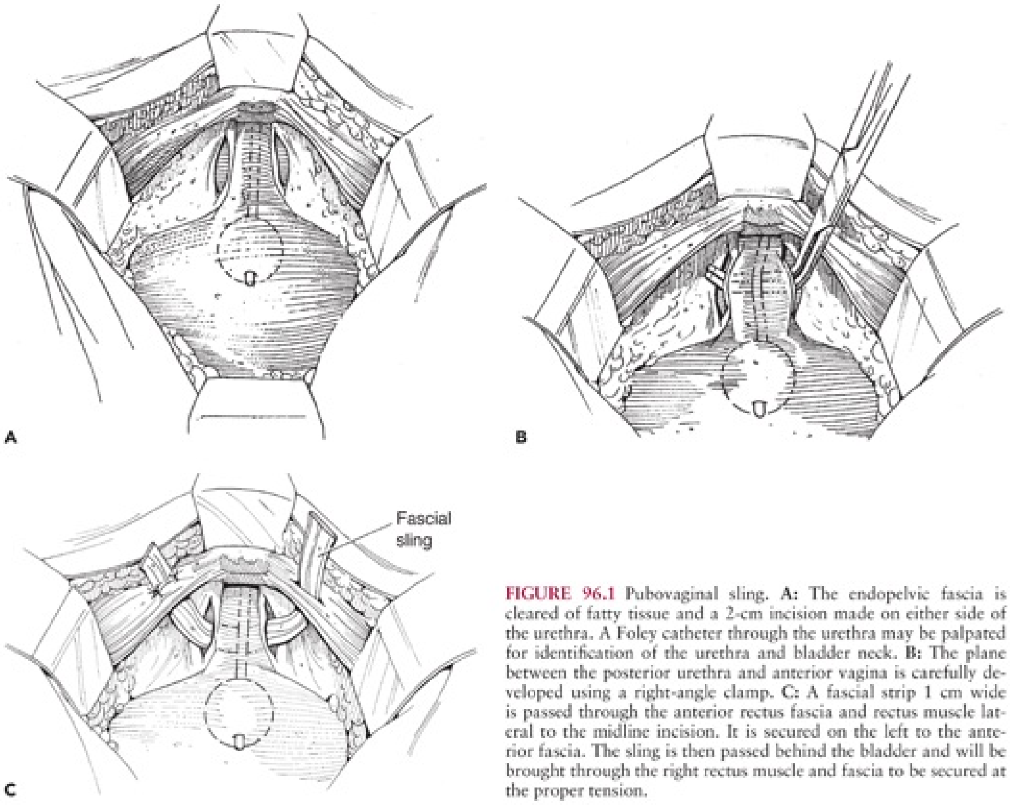

FIGURE 96.1 Pubovaginal sling. **A:** The endopelvic fascia is cleared of fatty tissue and a 2-cm incision made on either side of the urethra. A Foley catheter through the urethra may be palpated for identification of the urethra and bladder neck. **B:** The plane between the posterior urethra and anterior vagina is carefully developed using a right-angle clamp. **C:** A fascial strip 1 cm wide is passed through the anterior rectus fascia and rectus muscle lateral to the midline incision. It is secured on the left to the anterior fascia. The sling is then passed behind the bladder and will be brought through the right rectus muscle and fascia to be secured at the proper tension.

Once the proper plane is developed and the appropriate length of graft determined, a rectus abdominis fascial strip 1 cm in width and appropriate in length is harvested. The fascia may be taken in either a vertical or horizontal fashion depending on the initial incision. Fascia from other sites has been utilized but requires a second incision. Autologous cadaveric tissue or biodegradable scaffolds may also be used.

All of the grafts are in general brought through the rectus muscle and anterior rectus fascia on either side and approximated to the anterior rectus fascia using permanent sutures (Fig. 96.1C). If long enough, the two limbs of the sling may also be approximated to each other superficial to the fascia.

In patients with stress incontinence, the sling is placed tightly enough to maintain the proximal urethra and bladder neck in the appropriate anatomic position. Too snug of placement in such a setting may impede spontaneous voiding. When used for patients with neurogenic dysfunction who will not rely on spontaneous voiding, the sling may be pulled up more tightly to improve compression of the bladder neck and proximal urethra. If intermittent catheterization postoperatively will be performed through the native urethra, intraoperative catheterization should be repeated frequently to make sure the fascial sling is not placed so tight as to impede catheterization.

A commonly employed modification of the traditional suspensory sling, used by many reconstructive surgeons, is the wrap-around sling. In this modification, the sling material (fascial or other) is wrapped around the bladder neck completely prior to securing the free ends in the manner of a suspensory sling. The theoretic advantage of this approach is greater coaptation of the bladder neck tissue than with a traditional sling while preserving the ability to perform intermittent catheterization per urethra (8).

Young–Dees–Leadbetter Bladder Neck Repair

The Young–Dees–Leadbetter bladder neck repair is typically performed in the setting of exstrophy–epispadias complex in the modern staged repair of exstrophy and after epispadias repair. Ideally, it is performed when a patient's bladder capacity under anesthesia by gravity cystography is at least 85 mL and when the patient can participate in a strict postoperative voiding program (9). After bladder exstrophy closure, the procedure is typically performed through a lower midline incision. For patients with epispadias who do not require augmentation, the reconstruction may be done through a Pfannenstiel incision.

The anterior bladder is opened. This incision is carried as far distally into the proximal urethra as possible. Splitting of the intersymphyseal band with subsequent closure may allow closure and tapering of the proximal urethra. Virtually all exstrophy patients require antireflux surgery, and typically, the ureteral hiatus is initially quite low in the bladder. The ureters are mobilized and reimplanted into the bladder 3 to 4 cm more cephalad in location. Typically, the ureters are reimplanted with a cross-trigonal technique, although the tunnels may even be angled upward in a cephalad direction from the new hiatus. A 12- to 15-mm wide strip of mucosa is preserved in the posterior midline of the urethra and bladder trigone for reconstruction of the neourethra. Parallel incisions through mucosa are made on either side of this strip and the triangles of trigone mucosa on either side excised (Fig. 96.2A). Submucosal infiltration of dilute epinephrine in those two areas may aid in excision and decrease bleeding. The midline strip of mucosa and subsequent neourethra are typically made 4 to 6 cm long depending on how much proximal urethra is exposed and reconstructed. The midline strip is tubularized over an 8 Fr catheter using absorbable sutures to approximate the edges. This tubularization may be done with interrupted or running absorbable sutures but should be tension-free (Fig. 96.2B). Small purchases of the adjacent superficial muscle of the trigone may be included with the mucosa for strength. The closure is easier to begin distally and finished cephalad. The lateral flaps of trigone muscle are then wrapped over the neourethra in an overlapping fashion. To do so without tension, the muscle must be incised transversely at the cephalad margin of the mucosal excision. One flap of muscle is wrapped over the neourethra and approximated to the underside of the other muscle flap using interrupted, absorbable mattress sutures. The second flap of muscle is then wrapped over the first and approximated to the outside of the muscle, again with absorbable sutures (Fig. 96.2C). A soft urethral catheter is left in place during healing but should be secured so as to avoid tension on the neourethra. Ureteral stents or catheters are often left in place because of potential edema. The bladder is closed in two layers.

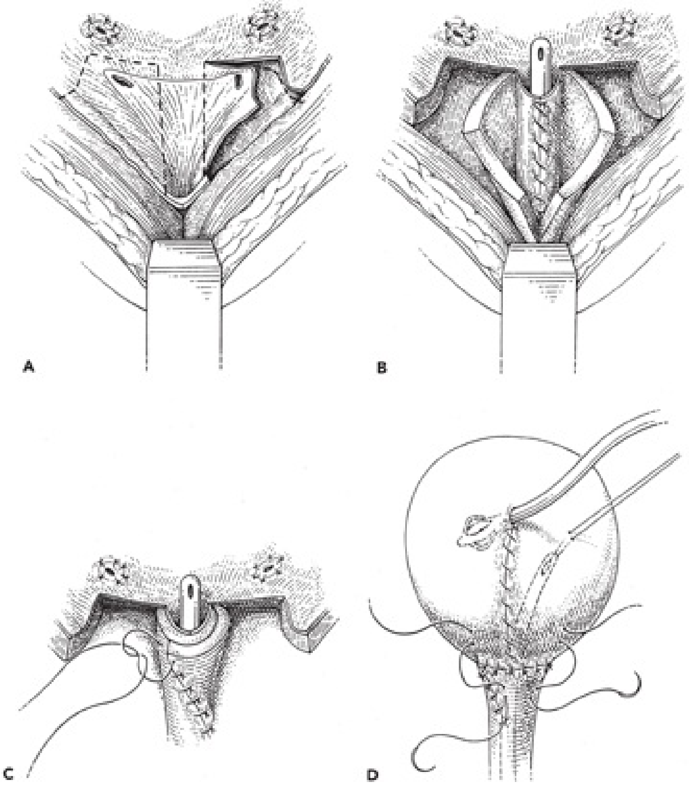

FIGURE 96.2 Young–Dees bladder neck repair. A: The trigone mucosa is incised to leave a posterior, central strip of mucosa 15 mm wide. The triangles of mucosa on either side are excised. The ureters have previously been reimplanted in a more cephalad position. B: The central mucosa strip is tubularized using a running absorbable suture. C: The lateral trigone muscle flaps are closed in an overlapping fashion around the neourethra. D: After completion of the bladder and urethral closure, several pairs of suspension sutures secure the urethra and bladder to the underside of the intersymphyseal band and lower abdominal wall.

If bladder augmentation is required, the bladder should be closed to itself for a short distance from the urethra prior to applying the bowel segment. A clear demarcation between the neourethra and bladder can often be seen after closure. Care should be taken that there is effective closure of the urethra and bladder at this junction. The bladder may tend to kink over the urethra at that level, and the neourethra and new bladder neck should be suspended to the undersurface of the intersymphyseal band and lower abdominal wall using several pairs of sutures as described for the Marshall–Marchetti–Krantz procedure (Fig. 96.2D).

Alternatively, Leadbetter described full-thickness, parallel incisions through the trigone mucosa and muscle on either side of the central strip. These incisions, again, made 12 to 15 mm apart, are started distally at the old bladder neck and continued in a cephalad direction for 4 to 5 cm (Fig. 96.3A). The central strip of mucosa is tubularized with interrupted or running absorbable sutures. The muscle of the central strip is closed as a second layer. If the incision through the muscle is made slightly wider than on the mucosa, the muscle may be approximated in an overlapping manner, but to a lesser degree than that described by Young and Dees. The lateral triangles of full-thickness trigone are left in continuity with the bladder and included in that closure (Fig. 96.3B).

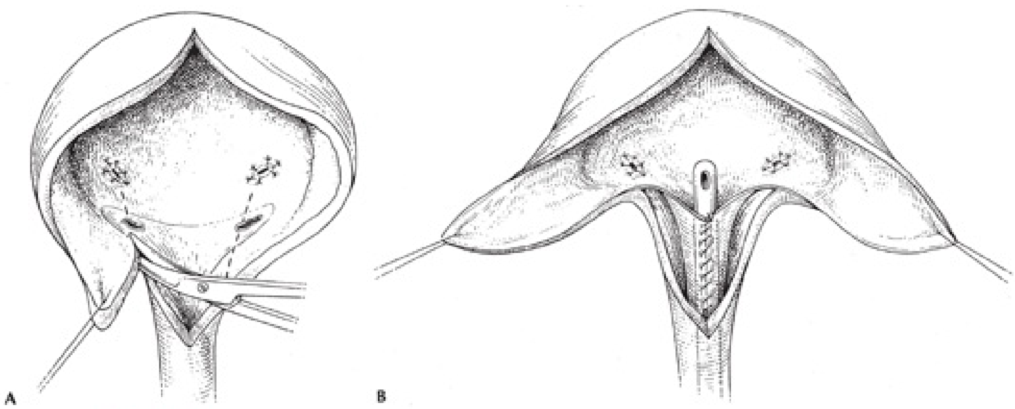

FIGURE 96.3 Leadbetter modification of Young–Dees–Leadbetter bladder neck repair. A: Full-thickness parallel incisions are made through the trigone mucosa and muscle, leaving a central strip 15 mm wide. B: The mucosa of the neourethra is tubularized using a running absorbable suture. The muscle is then closed. The lateral flaps of trigone are left in continuity with the bladder.

Kropp Urethral Lengthening Procedure

The bladder is exposed through a lower midline incision and the bladder neck is identified by palpation of a catheter placed through the urethra. A rectangular, full-thickness strip of anterior bladder is marked and incised. This strip is based at the bladder neck and should be left in continuity with the urethra (10). The incised strip measures 6 cm in length and 2 cm in width (Fig. 96.4A). Stay sutures placed at the cephalad corners of the strip aid in mobilization. The bladder cephalad to the strip is open in the midline. After anterior incision, the catheter is pulled over the pubis to expose the posterior bladder neck. This allows identification of the ureteral orifices, which are catheterized. If reflux is not present and the space between the orifices is adequate for urethral tunneling, ureteral reimplantation may not be necessary. The ureteral stents are often left in place for 4 to 5 days due to edema. Posterior incision of the mucosa at the bladder neck is performed using cutting current with the electrosurgical cautery to completely separate the neourethra from the bladder at the mucosal level. Further dissection through the posterior muscle in the midline is performed to allow smooth tubularization of the neourethra. Posterolateral musculoadventitial tissue at the 5 and 7 o’clock positions is left intact so that the bladder remains anchored in a caudal position. This eventually ensures that the tubularized neourethra reaches well into the bladder lumen to achieve an effective flap valve.

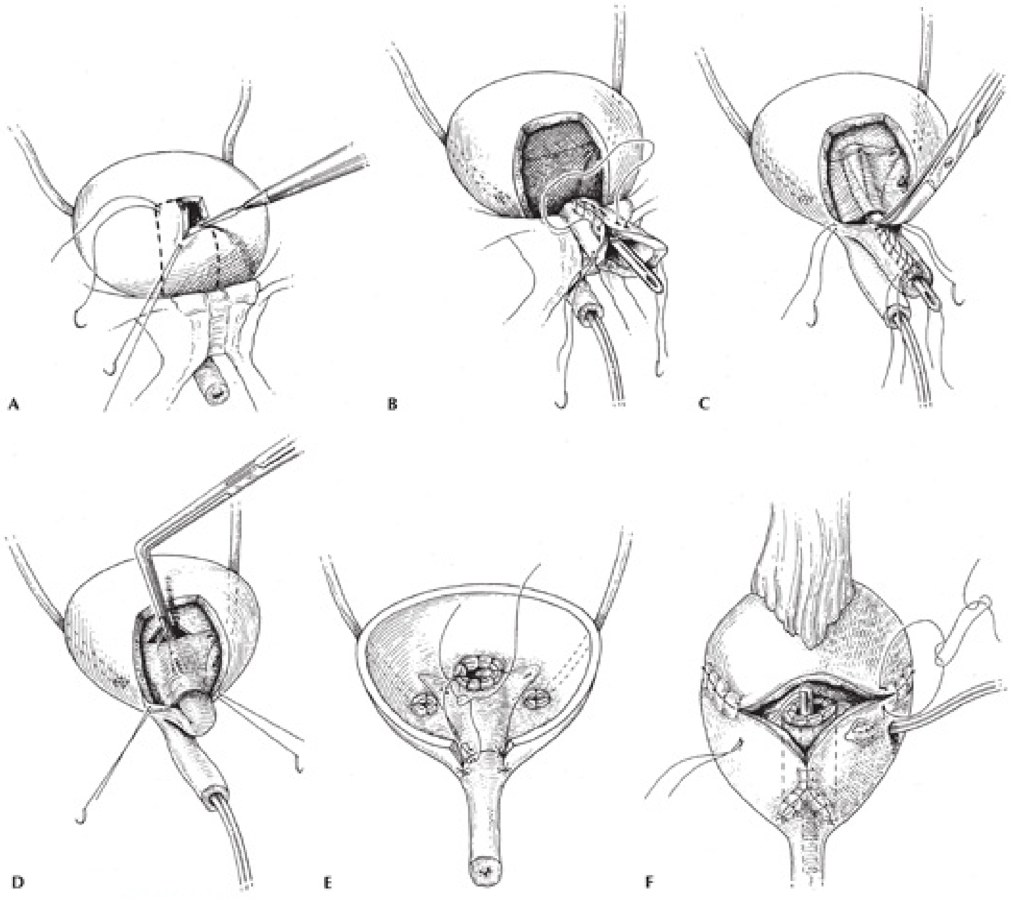

FIGURE 96.4 Kropp procedure for urethral lengthening. A: A 6 cm × 2 cm flap of anterior bladder is mobilized in continuity with the urethra. B: The flap is tubularized. C: The posterior mucosa is incised transversely at the bladder neck and a tunnel created for the neourethra from the old bladder neck to a position above the interureteric ridge. D: The neourethra is brought through the tunnel, taking care that it does not kink. Note that the posterolateral musculoadventitial tissue is intact and keeps the bladder anchored distally. E: The proximal end of the neourethra is trimmed flush with its orifice in the bladder. The end is approximated to the vesical mucosa circumferentially. F: The bladder is carefully closed distally by approximating the bladder muscle and mucosa to the adventitia of the neourethra. The neourethra extends well into the lumen of the bladder to create an effective flap valve. Bladder augmentation is performed when necessary.

The anterior bladder flap in continuity with the urethra is tubularized by approximating the mucosa and then muscle with continuous absorbable sutures (Fig. 96.4B). This closure is again begun distally and continued in a proximal or cephalad direction.

A submucosal tunnel is developed from the posterior bladder neck to a position several centimeters above the interureteric ridge (Fig. 96.4C). The more cephalad portion of this tunnel is easily developed from above and the more distal or caudal portion typically from the bladder neck (Fig. 96.4D). This tunnel must be made wide enough that the neourethra can be brought through in a nice smooth course. Care must be taken that there is no kink whatsoever at the entrance of the neourethra into the bladder at the area of the old bladder neck. Any kinking at that level will result in difficult catheterization.

Alternatively, the mucosa in the posterior midline may be incised for the entire length for the proposed tunnel. The mucosa on either side is then mobilized to create a wide trough into which to place the urethra. The mucosa from either side is then approximated to the adventitia of the neourethra and will eventually grow to cover it completely. The tubularized neourethra should not be redundant in length relative to the submucosal tunnel to minimize the risk of difficult catheterization. If necessary, excess length may be excised. The proximal end of the neourethra is approximated to the bladder mucosa at its orifice with interrupted absorbable suture (Fig. 96.4E). Distally, the lateral and anterior bladder is securely approximated to the adventitia and muscle of the urethra (Fig. 96.4F). This closure should be performed as distally as possible on the urethra to avoid foreshortening of the tunnel within the bladder. Ease of catheterization through the neourethra should be tested at each step of reconstruction and any problems addressed when noted. If augmentation of the bladder is necessary, the incision is extended and the peritoneal cavity entered. A short segment of distal bladder should be closed to itself up from the urethra prior to placing the segment for augmentation. A soft urethral catheter is left in place per urethra during healing. The catheter should be secured so as to avoid any pressure on the reconstructed urethra. The catheter is usually left in place for 4 to 6 weeks during healing, often with a suprapubic cystotomy tube as well. After a static cystogram demonstrates no leakage and good healing, self-catheterization may begin.

Pippi Salle Urethral Lengthening Procedure

In an effort to achieve the effective flap valve created with the Kropp procedure while decreasing the risk for problems with catheterization, Salle et al. (11) described a modification for urethral lengthening. The anterior bladder wall flap is used as an onlay and eventually contributes half of the circumference of the neourethra. Therefore, a full-thickness anterior bladder flap 5 cm × 1 cm is mobilized in continuity with the bladder neck (Fig. 96.5A). One millimeter of mucosa on either side is excised to avoid overlapping suture lines. Two parallel incisions through the mucosa of the trigone are made so as to leave a central strip of mucosa 8 to 10 mm in width and 5 cm in length. The lateral trigone mucosa on either side is mobilized to eventually close over the neourethra. The mucosa of the anterior flap is approximated to the midline strip of trigone mucosa using a running absorbable suture started distally (Fig. 96.5B). The muscle of the anterior flap is approximated to the superficial muscle on either side of the central mucosa (Fig. 96.5C). The trigone muscle on either side of the posterior mucosal strip may be incised superficially to provide an edge to which to sew the muscle of the anterior flap. Closure of the lateral mucosa of the trigone over the reconstructed neourethra creates a flap valve and a neourethra with an intact posterior wall (Fig. 96.5D and E). Distally, the muscle and mucosa of the bladder neck are approximated to the lateral and anterior adventitia and muscle of the neourethra as distally as possible. Proximally, the neourethra should extend well into the lumen of the bladder to create an effective flap-valve mechanism for continence. The neourethra and ureters are often stented temporarily in a manner similar to that described for the Kropp procedure (Fig. 96.5F).

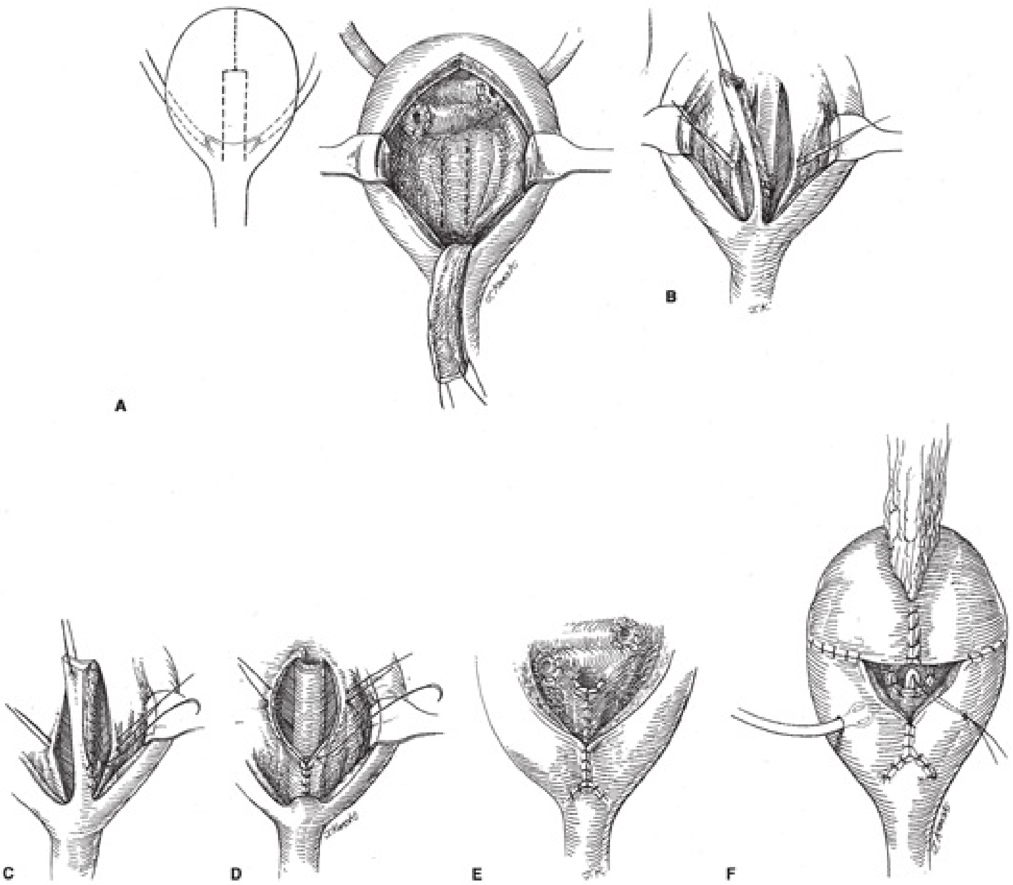

FIGURE 96.5 Pippi Salle procedure for urethral lengthening. **A:** A full-thickness, anterior bladder flap 5 cm × 1 cm is marked and incised. Parallel incisions through the trigone mucosa posteriorly leave a central strip of similar length and width. **B:** The lateral trigone mucosa is mobilized to cover the neourethra. The mucosa of the anterior flap is approximated to the edge of the central mucosal strip using a running absorbable suture. **C:** The muscle of the anterior flap is approximated to the superficial trigone muscle on either side of the mucosal closure. **D:** The lateral mucosa is closed over the neourethra. **E:** The distal bladder is closed to itself and carefully to the urethra. **F:** Bladder augmentation is performed when necessary.

Minimally Invasive Surgical Approaches

The relatively recent integration of robot-assisted laparoscopic surgery (RALS) into pediatric urology practice has facilitated development of minimally invasive complex reconstructive procedures. In this domain, initial reports describe feasibility and safety of RALS Mitrofanoff catheterizable conduit, Leadbetter/Mitchell bladder neck reconstruction, bladder neck sling, and augmentation cystoplasty. Theoretic advantages of RALS include decreased hospitalization, decreased analgesic requirements, improved cosmesis, and improved visualization. Data from large series or with long-term follow-up from RALS for bladder neck procedures is not yet available (12,13).

OUTCOMES

In the pediatric population, fascial slings have been used most extensively in patients with neurogenic sphincter incompetence. Long-term success with slings in that population has varied greatly, from 40% to 100%. Success rates have varied so much that it is not clear that any particular modification of the sling configuration results in any difference in terms of continence. Fascial slings have been used more extensively and with better results in girls with neurogenic dysfunction in whom the continence rate may reach 75% (14). The primary factor predictive of success has been thought to be concomitant enterocystoplasty to ensure a compliant bladder; although recently, the efficacy of sling and catheterizable conduit alone has emerged as an area of investigation (15). Patients undergoing bladder neck sling without enterocystoplasty are more likely to require postoperative anticholinergic therapy to maintain safe reservoir characteristics and are apt to have shorter catheterization intervals to maintain continence than those patients who undergo simultaneous enterocystoplasty (16). Sling placement does not in general interfere with the ability to perform intermittent catheterization, which is usually necessary in the patient population, but many surgeons will perform continent catheterizable conduit procedures (Mitrofanoff, Monti, etc.) simultaneously to facilitate independent catheterization.

The Young–Dees–Leadbetter bladder neck repair has been used most commonly in the classic staged reconstruction for bladder exstrophy. Continence with spontaneous voiding has been achieved in up to 80% of patients with exstrophy and may be even higher for patients with epispadias (17). Other authors have reported a lower continence rate, and even among patients considered dry, clinical and urodynamic problems related to poor emptying may exist (18). When used for patients with neurogenic dysfunction and denervated sphincter muscle, the procedure initially resulted in continence in approximately 25% of patients but can be improved to almost 70% if combined with bladder augmentation (19,20). Due to the high percentage of additional procedures required, the repair has in general fallen out of favor for patients with neurogenic dysfunction. Furthermore, reliable catheterization through the urethra after a Young–Dees–Leadbetter repair may be difficult.

The urethral lengthening procedures have primarily been used in boys with neurogenic bladder dysfunction. Using the technique described by Kropp, continence has been achieved in 75% to 90% of such patients (10,21). Difficulty with catheterization has been reported in 40% of male patients in some series, although that incidence may be lowered when the posterior urethra is not totally transected (21). Because of concerns about the potential problem with catheterization, some surgeons prefer routine construction of a continent catheterizable stoma (22). A significant incidence of new reflux has been apparent in some series using the Kropp technique (22). Using Salle et al.'s modification, less trouble with catheterization in males has been noted, although continence rates have not been quite as high (23,24). Urethrovesical fistula and partial necrosis of the intravesical neourethra have on occasion resulted in incontinence after the repair, and widening the base of the anterior flap at the level of the bladder neck may decrease those problems.

Recent work has begun to address the impact of lower urinary tract reconstruction on health care–related quality of life for patients with neurogenic bladder and exstrophy–epispadias complex. It is not possible to determine the specific effect of vesical neck reconstruction on quality of life from the available literature because vesical neck reconstruction is often performed in conjunction with or in a series of other reconstructive procedures. The limited existing literature, however, has not demonstrated that attainment of urinary continence leads to significant improvement in overall quality of life in either of these patient groups. Further investigation with other metrics or larger sample sizes may demonstrate a positive effect of lower urinary tract reconstruction (25,26).

Complications

Relatively common clinical problems after bladder neck reconstruction include urinary tract infection and bladder stones. Both may occur in exstrophy patients after Young–Dees–Leadbetter bladder neck repair due to poor emptying (18) but are even more common among patients with neurogenic dysfunction requiring intermittent catheterization, in particular if bladder augmentation has been performed. The urethral sling and the artificial urinary sphincter possess unique complications that are related to their periurethral placement or mechanical and synthetic characteristics. Urethral erosion, although low with fascial slings and 5% to 15% of artificial urethral sphincters, is most commonly related to infection. Erosion is a leading cause for permanent failure of the artificial urinary sphincter. Additionally, mechanical problems or tissue atrophy at the cuff lead to artificial urinary sphincter revision rates of approximately one in four in modern series (27). Although highly effective, bladder neck division carries the unique risk of urethral incontinence secondary to vesicourethral fistula. This complication can require multiple interventions to correct and is best prevented by radical mobilization of the bladder neck posteriorly and tissue interposition between the transected bladder neck and proximal urethra. Effective interposition can be achieved with local tissue, omental flaps, rotational muscle flaps, or biosynthetic materials (28).

It is important to perform routine surveillance for hydronephrosis of the upper urinary tract with ultrasonography after any form bladder neck repair. This is particularly true among patients with neurogenic dysfunction if they have not undergone bladder augmentation. Even if the bladder appeared adequate prior to outlet reconstruction, up to one-quarter of patients may develop bladder hostility after an increase in outlet resistance, which may silently threaten the kidneys (29).

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CHAPTER 97 SURGERY FOR POSTERIOR URETHRAL VALVES

ROSALIA MISSERI AND KENNETH I. GLASSBERG

A posterior urethral valve (PUV) is the most common cause of congenital bladder outlet obstruction in boys. It is associated with a dilated posterior urethra, poor urinary stream, and incomplete bladder emptying. Bilateral hydroureteronephrosis of varying degrees is almost always present and frequently accompanied by vesicoureteral reflux and/or bladder diverticula.

DIAGNOSIS

With the widespread use of antenatal ultrasound, PUVs are often diagnosed prenatally. The condition is suspected in utero when a male fetus is found to have bilateral hydroureteronephrosis and a thick-walled bladder that does not empty completely on sonography. In addition, there may be a keyhole deformity noted on sonography. This is noted when a dilated bladder and posterior urethra is seen. In severely affected fetuses, oligohydramnios, pulmonary hypoplasia, and Potter syndrome may occur. Newborns may present with abdominal masses representing a distended bladder or hydronephrotic kidney, dry diapers, nonspecific gastrointestinal symptoms, respiratory distress, or urinary ascites. Younger boys usually present with urinary tract infection, respiratory distress, abdominal distention, sepsis, or azotemia, while older boys may present with dysfunctional voiding symptomatology, incontinence, poor urinary stream, urinary tract infections, or hematuria.

If a PUV is suspected in an infant based on antenatal ultrasound evaluation, prophylactic antibiotics should be initiated, and the bladder should be drained with a 5Fr or 8Fr feeding tube securely taped in place with a clear transparent dressing. Positioning is best confirmed with an abdominal radiograph as the tube may coil in the dilated posterior urethra. The feeding tube is left in place until a voiding cystourethrogram (VCUG) is obtained to make the diagnosis. A baseline postnatal ultrasound is routinely obtained to evaluate the renal parenchyma and degree of hydronephrosis. Serum chemistries, blood urea nitrogen and creatinine, should be obtained after 24 hours of life because labs in the first 24 hours reflect the mother's serum values. In patients with severe hydroureteronephrosis and/or azotemia, the catheter should be left in place until the azotemia resolves/stabilizes and hydroureteronephrosis improves.

The VCUG of a boy with a PUV will reveal a posterior urethra that appears dilated, often taking on a "shield shape" or squared-off appearance. The bladder neck is often clearly demarcated and may appear as a thick collar, and the urethra distal to the obstruction will appear less full or more narrow than normal (Fig. 97.1). Vesicoureteral reflux may be present in about 25% to 50% of boys with vesicoureteral reflux and is most often related to bladder outlet obstruction due to PUVs (1–4).

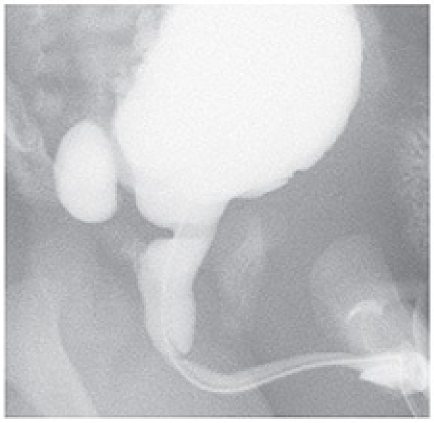

FIGURE 97.1 VCUG of newborn with PUVs. Note the dilated posterior urethra and bladder diverticulum.

INDICATIONS FOR SURGERY

Although some controversy still exists as to what to do once the bladder has been drained with a catheter, almost all valves are currently treated with transurethral ablation (Fig. 97.2). For severe hydronephrosis, some report better long-term outcomes when these infants are temporarily diverted, while most feel that primary valve ablation is the treatment of choice (5). For those who believe temporary diversion is best, many methods of vesical and supravesical diversion of the obstructed bladder exist.

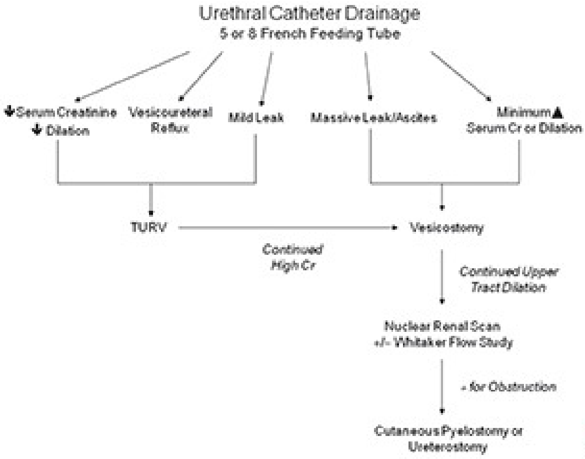
Urethral Catheter Drainage
5 or 8 French Feeding Tube
↓ Serum Creatinine ↓ Dilation
Vesicoureteral Reflux
Mild Leak
Massive Leak/Ascites
Minimum ▲ Serum Cr or Dilation
TURV
Vesicostomy
Continued High Cr
Continued Upper Tract Dilation
Nuclear Renal Scan +/- Whitaker Flow Study
+ for Obstruction
Cutaneous Pyelostomy or Ureterostomy

FIGURE 97.2 Proposed management of PUVs. *Cr*, creatinine; *TURV*, transurethral valve ablation.

ALTERNATIVE THERAPY

There is no effective alternative to surgical therapy. Antenatal attempts at valve ablation, transurethral stenting, and percutaneous vesicoamniotic shunting are offered at few select centers and remain quite controversial.

SURGICAL TECHNIQUE

Transurethral Valve Ablation

Valve ablation is most commonly accomplished transurethrally. The size of the infant's fossa navicularis usually limits the size of cystoscope that may be used. Typically, a 7.5Fr or 8.5Fr scope is used in infants, while a larger scope may be used in older children. The cystoscope should be well lubricated and advanced under direct vision. Gentle dilation of the distal urethra may be required to advance the cystourethroscope. With the bladder full and applying gentle suprapubic pressure, the valve leaflets are more easily seen coming off the verumontanum and extending distally to fuse anteriorly (Fig. 97.3). The goal of valve ablation is to disrupt the leaflet, hence destroying the obstruction.

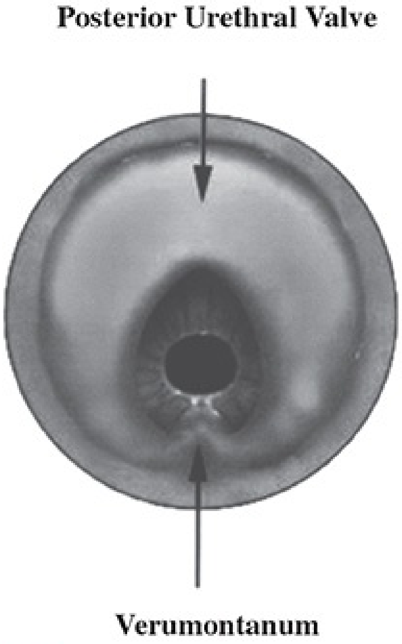

FIGURE 97.3 Cystoscopic appearance of type 1 PUV.

A PUV may be ablated or incised in several ways. The decision to proceed with one technique over another is often based on surgeon preference, availability of equipment, and the size of the child's urethra. The valve may be ablated using a 3Fr Bugbee electrode through a cystoscope. Alternatively, the wire insert of a 3Fr ureteral catheter with the distal end connected to electrocautery may be used. All but the tip of the wire is insulted by the catheter to avoid thermal injury. Once in position, the Bugbee or wire is advanced and pushed into the valve at the 5 and 7 o'clock positions while employing a cutting current of 20 to 25 W. (Note that power settings may vary from machine to machine.) When using cautery, care must be taken to ensure that thermal energy is targeted at the valves alone. The holmium:YAG laser may also be used to incise the valves (6). These techniques may be particularly useful if the infant resectoscope is too large for the child's urethra.

When using a small pediatric resectoscope, the valves are incised with a right-angle hook, loop electrode, or hook-shaped cold knife. When using a loop electrode, a narrow, more oblong loop is preferable to a wider, more circular loop. Some debate exists as to the best location for valve incision. Williams et al. (4) preferred incising at the 12 o'clock position, while Gonzales (7) advocated cutting at the 4, 8, and 12 o'clock positions. However, many prefer incising at the 4 to 5 o'clock and 7 to 8 o'clock positions using a hook-shaped cold knife or with the cutting current set at 20 to 25 W pure cut.

Additional methods of PUV ablation have also been described for use in patients with small-caliber urethras that do not allow passage of even the smallest cystoscope. With the advent of smaller scopes, perineal urethrostomy is now rarely necessary for valve ablation. Zaontz and Firlit (8) have described percutaneous antegrade ablation of PUV as well as antegrade incision of PUV in infants with small-caliber urethras. At our institutions, small or premature infants who are critically ill and cannot be successfully catheterized have had percutaneous suprapubic catheters placed at the bedside.

Once the valves are endoscopically ablated, the bladder should be cystoscoped to evaluate for diverticula, trabeculations, and the appearance of the ureteral orifices. A full stream should be noted at the end of the procedure while applying gentle pressure to the suprapubic area. A small urethral catheter is left in place for 1 to 2 days following the procedure or until an elevated creatinine nadirs. Repeat serum electrolytes and creatinine should be obtained 24 hours after catheter removal while the boy is still hospitalized. A renal ultrasound is useful in the postoperative period to evaluate for improvements in hydronephrosis. Its timing should be dictated by the surgeon's level of concern. A VCUG may be performed after the catheter is removed to assess the success of the procedure. Timing of the VCUG is determined by the surgeon based on his or her confidence in the adequacy of ablation. The urethra, degree of reflux, and bladder appearance should be evaluated on VCUG. A VCUG and urodynamics or preferably videourodynamics should be delayed no longer than 6 to 8 weeks after ablation. If there is suspicion of inadequate ablation or continued obstruction, "second-look" cystoscopy with ablation of residual leaflets should be considered. Some have recommended routine cystoscopy a few weeks after valve ablation because of the high incidence of residual obstruction (9).

Follow-up renal ultrasound and serum creatinine and electrolytes should be performed at the time of the VCUG and urodynamics but may be obtained sooner based on the child's renal function and clinical presentation.

If the child is found to have diminished compliance or detrusor hyperactivity, anticholinergic therapy should be considered. Anticholinergic therapy may also be instituted immediately after valve ablation or prior to closure or reversal of vesical or supravesical diversion. Alpha-blocker therapy may be considered even in the first months of life in the face of high detrusor voiding pressures and in the absence of residual valve obstruction or postvalve ablation stricture (10,11).

Vesicostomy

While most patients with PUV are treated with primary valve ablation, a vesicostomy may be useful in neonates whose urethra will not accommodate a cystoscope or in those whose creatinine rises despite adequate valve resection.

With the patient in the supine position, the lower abdominal skin is prepared and draped in the typical fashion. The procedure is more easily performed with a full bladder. A 2-cm transverse incision is then made midway between the pubic symphysis and umbilicus. The rectus fascia is exposed and a 2 cm × 2 cm cruciate incision is made. Alternately, a triangle or circle of rectus fascia measuring 2 cm may be excised. One must remember that the size of the fascial opening ultimately determines the caliber of the stoma. The rectus muscles are then retracted laterally, exposing the bladder. A 3-0 suture is placed near the dome of the bladder and used for traction. Using the traction suture, the bladder is mobilized superiorly. The peritoneum is gently swept off the superior aspect of the bladder. Additional cephalad sutures may be placed in a stepwise fashion to help bring the dome into the surgical field. Care is taken to avoid the peritoneal contents. With gentle traction, one should be able to visualize the urachus or obliterated hypogastric artery.

The vesicostomy may be created in one of two ways. In the first method, a stay suture is placed proximal to the urachus. The urachus is then transected and excised. In the second method, the portion of the bladder cephalad to the urachal remnant is used as the site for the vesicostomy. The bladder is incised and the fascial edges are sewn to the outer bladder wall using 3-0 or 4-0 polyglactin sutures approximately 0.5 to 1 cm from the opening created in the bladder. The vesicostomy should be calibrated to 24Fr or large enough to allow passage of the surgeon's fifth digit. If the fascial defect is too large, interrupted 3-0 polyglactin sutures may be used to narrow the opening. The edges of the detrusor are then sewn to the skin using 4-0 polyglactin sutures in an interrupted fashion. If the skin incision is wider than the stoma created, the skin is approximated with a suture of choice (Fig. 97.4).

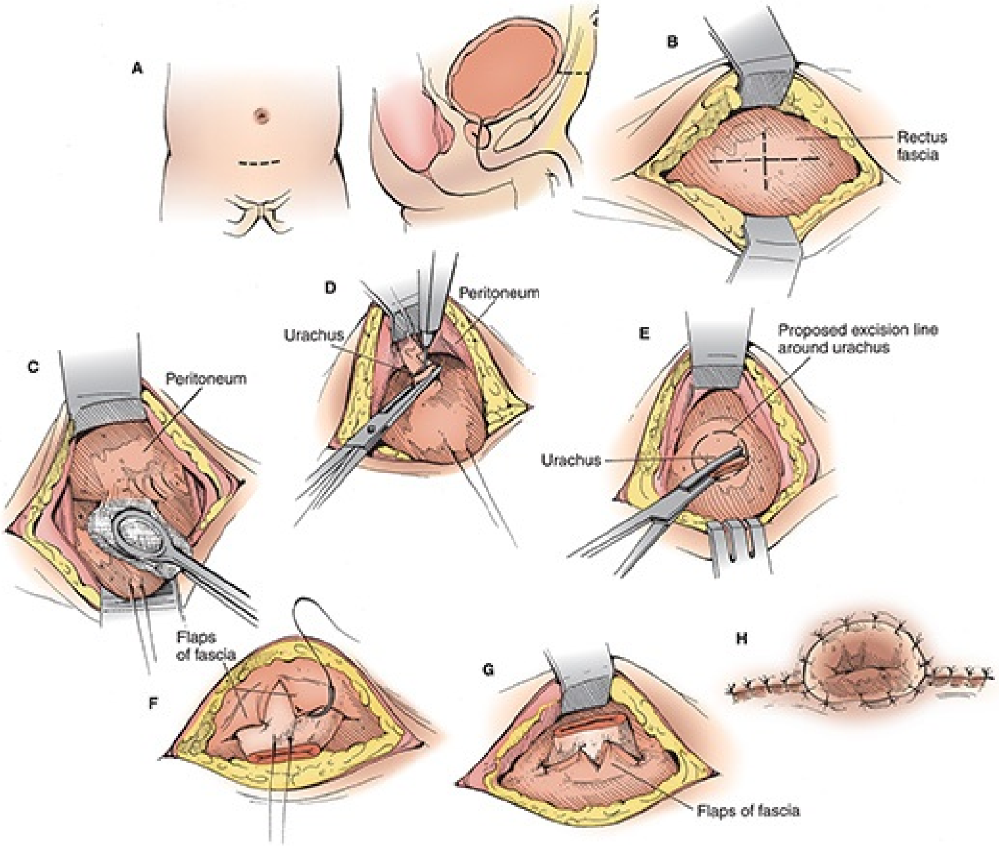

FIGURE 97.4 Blocksom vesicostomy. **A:** A 2-cm transverse incision is made midway between the pubic symphysis and umbilicus. **B:** A 2 cm × 2 cm cruciate fascial incision is made. **C:** Using the traction suture the bladder is mobilized superiorly. The peritoneum is gently swept off the superior aspect of the bladder. **D:** The urachus is incised and the bladder is further mobilized. **E:** The urachus is excised. **F and G:** The outer bladder wall is sewn to the edges of the incised rectus fascia. **H:** The edges of the detrusor are sewn to the skin. (Modified with permission from Belman AB, King LR. Vesicostomy: useful means of reversible urinary diversion in selected infant. *Urology* 1973;1:208–213. Copyright © 1973. Published by Elsevier Inc.)

The decision to close a vesicostomy should be made only once bladder dynamics have been assessed, and renal function and hydronephrosis have stabilized. A plan for permanent therapy should be devised prior to closure. Although some argue that urodynamic studies may be of little use because leakage may occur around the vesicostomy even with a Foley balloon occluding it and high grade reflux may give the impression of normal tracing, a well-performed study that shows adequate capacity with normal storage pressures is reassuring (12).

Ultimately, the timing of closure is dictated by the surgeon's philosophy. Some believe an empty bladder becomes a contracted bladder, while others close vesicostomies just prior to the expected time of potty training. Careful follow-up with renal ultrasounds, serum electrolytes, and creatinine is essential because some children may have poor bladder dynamics after closure of the vesicostomy.

For closure of a vesicostomy, an adequate-size balloon catheter is placed into the stoma of the vesicostomy. With the catheter in the bladder and the balloon inflated, an elliptical skin incision is made around the stoma. The subcutaneous and perivesical tissues are dissected circumferentially around the vesicostomy. Next, 3-0 chromic stay sutures are placed through the bladder wall approximately 1 cm cephalad and 1 cm caudad to the stoma. The skin and protruding portion of the bladder are excised. The previously placed catheter is removed and a urethral catheter is placed for bladder drainage. The bladder defect is then closed in two layers: a running 4-0 chromic suture is used to reapproximate the bladder mucosa, followed by interrupted or running 3-0 polyglactin or chromic sutures as a second layer. The remainder of the wound is closed in a standard fashion.

Supravesical Diversion

Cutaneous Pyelostomy

The decision to proceed with a supravesical diversion remains controversial, and it is rarely used. Some urologists feel that the failure of the creatinine to improve is related to a secondary ureterovesical obstruction and advocate supravesical diversion (7). To safely perform a cutaneous pyelostomy, the renal pelvis should be sufficiently dilated to avoid tension on the renal pelvis as it is pulled toward the abdominal wall. A dilated renal pelvis also ensures that dissection can be carried out away from the ureteropelvic junction (UPJ).

The renal pelvis may be approached in several ways, including a dorsal lumbotomy or a subcostal extraperitoneal approach. A surgeon may use the approach he or she is most comfortable with. Despite the limited exposure that a dorsal lumbotomy incision affords, it is excellent for visualization of the renal pelvis and upper ureter. The procedure avoids a muscle-cutting incision and may produce less postoperative pain.

When using a dorsal lumbotomy approach, the patient is intubated and then placed in the prone position on the operating room table. Cushions should then be placed under the chest and just superior to the anterior superior iliac spines. The landmarks include the 12th rib superiorly, the iliac crest inferiorly, and the lateral border of the sacrospinalis medially. A vertical incision with or without a slight curve at its distal end is made approximately one-third to one-half the distance between the 12th rib and the iliac crest. Alternatively, an oblique incision may be made along the Langer lines (Fig. 97.5). Care should be taken to avoid injuring the subcostal neurovascular bundle. The lumbodorsal fascia is exposed by elevating the skin and subcutaneous tissues for about 3 cm on either side of the incision so that a vertical fascial incision may be comfortably made. The posterior layer of the lumbodorsal fascia is incised vertically 2 cm lateral to the midline. The sacrospinalis muscle is then retracted medially. This exposes the middle layer of the lumbodorsal fascia, which is incised at the lateral border of the quadratus lumborum. Retracting the quadratus lumborum medially, the anterior layer of the lumbodorsal fascia is exposed (Fig. 97.6). This layer and the transversalis fascia are then incised between the subcostal and iliohypogastric nerves. The perinephric fat should then be in view. The kidney should be located in the superomedial part of the wound.

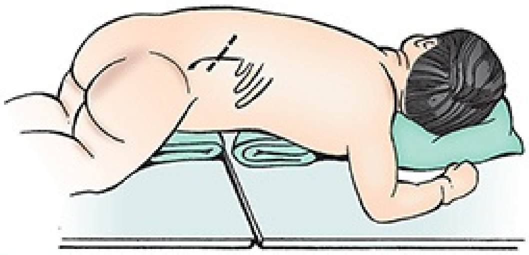

FIGURE 97.5 Positioning for dorsal lumbotomy and possible skin incisions. The *solid line* represents our incision of choice; the *broken line* represents a suitable alternative.

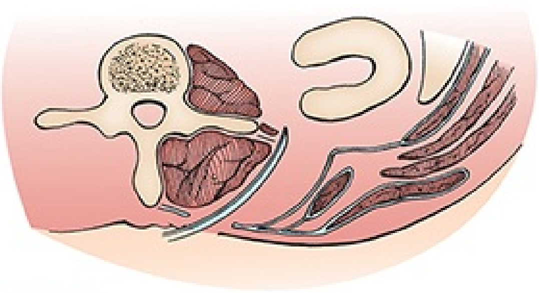

FIGURE 97.6 Fascial incision through lumbodorsal fascia lateral to the sacrospinalis and quadratus lumborum, avoiding the division of muscles as indicated by blue line.

When using a subcostal approach, the child should be placed in a lateral decubitus procedure or in a semi-oblique position with the shoulder turned 30 to 40 degrees. An incision is made off the tip of 11th or 12th rib based on renal anatomy and is extended toward the umbilicus for 2 to 4 cm depending on the child’s size. The subcutaneous tissues are divided with electrocautery, exposing the external oblique muscle laterally and the rectus sheath medially. Once the fibers of the latissimus dorsi muscle are divided in the lateral aspect of the wound, the external oblique muscle and internal oblique muscle layers are split or transected. Care should be taken to avoid injuring the subcostal neurovascular bundle located between the internal oblique and transversalis abdominis muscle layer. The lumbodorsal fascia is entered laterally, and the peritoneum is reflected anteriorly from the undersurface of the transversalis fascia using blunt dissection with a Kittner. The transversus abdominis muscle and the transversalis fascia are split or divided exposing the underlying peritoneum. The retroperitoneal space is entered laterally while retracting the peritoneum and its contents medially. Gerota fascia is entered over the lateral aspect of the kidney.

Once Gerota fascia is entered in the dorsal lumbotomy approach, the dilated renal pelvis is identified and rotated anteromedially. In the subcostal approach, the dilated renal pelvis is identified and rotated posterolaterally. The surgeon must assess if the pelvis can comfortably reach the skin. If not, a very proximal portion of the ureter may be brought out to serve the same purpose. Care should be taken to avoid dissection near the UPJ so as to avoid the possibility of a future UPJ obstruction. Two 3-0 chromic traction sutures are placed on the posterior aspect of the renal pelvis in the dorsal lumbotomy approach and anterior pelvis in the subcostal approach away from the UPJ. Using a scalpel, a 3-cm incision is made. The full thickness of the renal pelvis is sutured to the posterior corner of the skin incision using multiple interrupted 4-0 polyglactin sutures (Fig. 97.7). The pyelostomy should be calibrated to approximately 20Fr to avoid future stenosis or prolapse. Once the planned procedure has been performed, the posterior layer of the lumbodorsal fascia is reapproximated with 3-0 polyglactin sutures and the skin is then closed with either a subcuticular suture or skin staples.

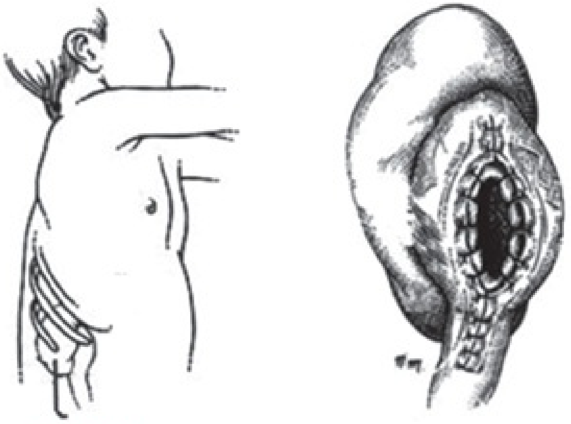

FIGURE 97.7 Cutaneous pyelostomy (sutures at the skin level).

High Cutaneous Loop Ureterostomy

This method is typically employed when the renal pelvis is not large enough for a cutaneous pyelostomy to be performed. The initial steps for a high cutaneous ureterostomy are similar to that for a cutaneous pyelostomy. The ureter is brought to skin level. Two 4-0 polyglactin sutures are placed in the upper ureter approximately 5 mm from each other. Using a scalpel, a 2-cm vertical ureterotomy is created. The abdominal musculature is closed on either side and behind the loop of ureter. Care is taken to avoid strangulating the ureter. The incised ureteral margins are sewn to the skin using interrupted 4-0 polyglactin sutures. The final product is a double-barreled ureteral stoma (Fig. 97.8).

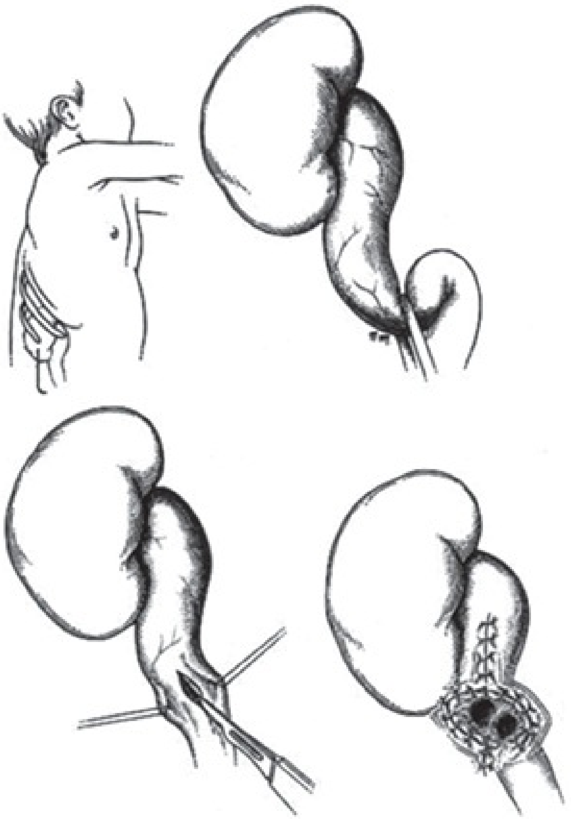

FIGURE 97.8 Loop cutaneous ureterostomy (sutures at the skin level).

Loop ureterostomies maintain continuity of part of the ureter, therefore decreasing the likelihood of disruption of ureteral blood supply and possibly making closure of the ureterostomy simpler.

Pelvioureterostomy-en-Y (Sober Loop Ureterostomy)

The Sober Y ureterostomy allows some urine to drain into the bladder, thus avoiding a completely defunctionalized bladder that may eventually become contracted (13). It is not the procedure of choice in critically ill patients as it is more extensive and time-consuming than other forms of diversion, and it is best used in patients with redundant tortuous ureters. The ureter is mobilized from the level of the kidney to the level of the true pelvis. The ureter is divided at a point where the lower ureteral segment comfortably reaches the renal pelvis. The upper ureter that remains in continuity with the renal pelvis is brought out to the flank caudad to the flank incision. The proximal end of the lower portion of the transected ureter is anastomosed to the renal pelvis. This is done in an end-to-side fashion after creating a pelviotomy at a point that will not cause ureteral kinking. The anastomosis is performed using a 6-0 or 7-0 polyglactin suture in a running fashion (Fig. 97.9). The flank incision is closed in the standard fashion. A small Penrose drain may be temporarily placed. Initially, most urine will drain via the ureterostomy. Over time, increasing amounts of urine will drain into the bladder.

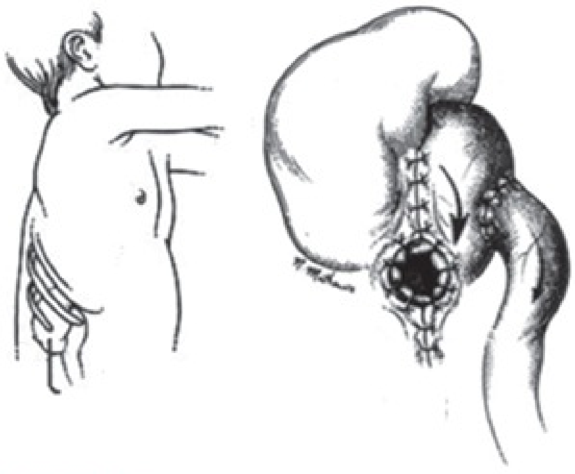

FIGURE 97.9 Pelvioureterostomy-en-Y (Sober ureterostomy).

Percutaneous Nephrostomy Tube

This procedure is typically performed with ultrasound guidance by interventional radiologists. Once access to the dilated renal pelvis is obtained, a pigtail catheter is placed. Ghali and colleagues (14) propose placement of a percutaneous nephrostomy tube prior to formal supravesical diversion because supravesical diversion will rarely prevent progression to renal insufficiency. In addition, tube placement allows for antegrade nephrostogram and pressure flow studies to confirm ureterovesical junction obstruction (14). This minimally invasive technique is also particularly useful in septic or otherwise critically ill children. Despite the ease of the procedure, tubes may become dislodged and formal diversion may be more difficult secondary to inflammatory reaction to the tube placement.

End Cutaneous Ureterostomy

To successfully perform a cutaneous ureterostomy, the ureter must be sufficiently thick-walled and dilated. Preservation of the ureteral blood supply is essential. The ureter should be approached extraperitoneally via either a Pfannenstiel or Gibson incision. The ureter should be carefully dissected from the level of the sacral promontory to the bladder with care to avoid stripping the ureter's adventitia. Once dissected, a thick vessel loop or Penrose drain should be placed around the ureter. One should estimate whether the ligated ureter will comfortably reach the anterior abdominal wall at the right or left lower quadrant. Once satisfied with this, the ureter is clamped and cut. The distal segment is ligated using a 3-0 polyglactin suture. A 3-0 polyglactin stay suture is placed on the cut end with care to avoid the ureter's medial blood supply (Fig. 97.10).

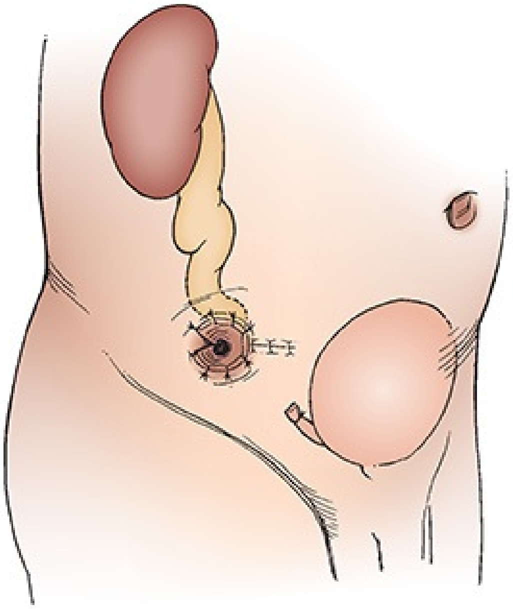

FIGURE 97.10 End ureterostomy (sutures at skin level). (From Indiana University School of Medicine, Office of Visual Media, with permission).

The cutaneous stoma is then created. Stomas should be placed in the right or left lower quadrant for ease of stomal fit in the event an appliance will be used or to ensure it is well covered by a diaper. Once the site of the stoma has been determined, a V-shaped incision is made and taken down through the subcutaneous tissues and rectus sheath. Using the previously placed stay suture, the ureter is gently brought through the incision. If the ureter seems stretched, additional mobilization may be necessary. The ureter is then spatulated medially to avoid its blood supply. The apex of the spatulated ureter is then sewn to the apex of the skin incision using a 4-0 polyglactin suture. The ureter is then sewn to the other angles of the skin incision and additional sutures are placed circumferentially.

Bilateral end ureterostomies may be brought to the midline or either lower quadrant. The medial wall of each ureter is incised approximately 3 cm. The apexes of the incised ureters are sewn to each other using a two-armed 5-0 polyglactin suture. The incised walls of the ureters are then sewn to each other in a running fashion.

Closure of Supravesical Diversions

To close a cutaneous pyelostomy, an elliptical skin incision is made around the stoma. The portion of pelvis that has been exteriorized is trimmed so that healthy renal pelvic edges may be approximated. Using a 6-0 polyglactin suture in a running fashion, the renal pelvis is closed in a transverse fashion. The UPJ should be inspected to ensure that no kinking has occurred secondary to pyelostomy closure.

To close a loop ureterostomy, an elliptical skin incision is made in the skin surrounding the stoma. The proximal and distal ureteral segments are adequately mobilized. The fibrotic exposed portions of the ureter are excised while trying to maintain the continuity of the ureter's back wall and blood supply. The remaining ureteral margins are then spatulated and closed in a transverse fashion using a 6-0 polyglactin suture (Fig. 97.11). Again, one must ensure that no angulation or narrowing of the ureter has occurred. A temporary indwelling ureteral stent may be placed to bridge the anastomosis.

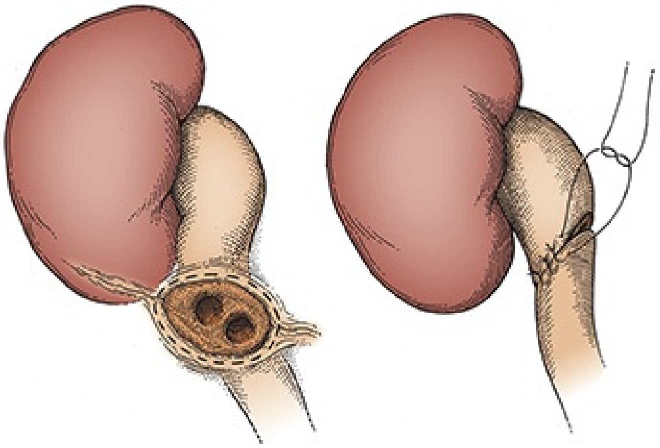

FIGURE 97.11 Takedown of loop cutaneous ureterostomy.

A Sober ureterostomy may be reversed by excising the stoma at the skin level along with the limb of ureter used to create the cutaneous ureterostomy. The dissection is taken down to the level of the renal pelvis. The defect in the renal pelvis is closed using a 6-0 polyglactin suture in a running watertight fashion.

Cutaneous end ureterostomies are taken down and a ureteral reimplant is performed. Ureteral tapering is often required. If ureteral length is deficient, a psoas hitch, Boari flap, or transureteroureterostomy may become necessary.

OUTCOMES

Complications

Transurethral resection of PUVs may result in urethral stricture or sphincteric incontinence. The report incidence of stricture varies from 2% to 50%, with some authors finding an increased incidence with the use of cautery (15–17). The use of appropriately sized resectoscopes, limited cautery, and good visualization with care to identify the external sphincter during resection are essential to avoid these complications. As with any urologic procedure, there is also a risk of urinary tract infection. A preoperative urine culture should be obtained and treated appropriately prior to any intervention.

Cutaneous vesicostomies may be complicated by early or late prolapse of the dome or posterior bladder wall in up to 17% of patients (18). To prevent prolapse, the most cephalad portion of the bladder or the urachus should be used as the site for the vesicostomy. By employing this portion of the bladder, the peritonealized part of the dome becomes immobilized, decreasing the risk of prolapse. The stomal opening itself should be no larger than 2 cm. The final stoma should calibrate to 24Fr. Excessive mucosal eversion should not be mistaken for prolapse. Despite its appearance, no intervention is necessary for excessive eversion.

If the vesicostomy does not appear to be draining well and there is evidence of large amounts of residual bladder urine or large amounts of urine are voided by urethra, the suspicion of stomal stenosis should be raised. Stomal stenosis rates of 3% to 12% have been reported (18). The stenosis may be secondary to a small fascial opening or excessive tension on the vesicocutaneous anastomosis. Continuous drainage of urine into a diaper commonly may lead to peristomal dermatitis. Prolonged, severe dermatitis may ultimately lead to stomal stenosis. This can be prevented by air drying the skin or applying topical ointments used for diaper rash. Fungal superinfections may occur and are treated with antifungal creams and powders.

Some infants, particularly those with persistent vesicoureteral reflux, may have recurrent urinary tract infections despite patent vesicostomy and small bladder residuals. These children may benefit from intermittent catheterization through their vesicostomies.

The most common complication associated with pyelostomy is chronic skin irritation and dermatitis. As in other forms of diversion, chronic bacteriuria is also common. Less common complications of pyelostomy include stomal stenosis and prolapse of the renal pelvis. Chronic bacteriuria has been found in approximately two-thirds of patients with ureterostomies and is the most common complication in this group. Stomal stenosis occurs in 11% to 70% of patients undergoing end cutaneous ureterostomies (19). The incidence of stenosis and obstruction is related to the caliber of the ureter used as well as the type of stoma created. Chronic skin irritation may also result in scarring and stenosis.

Results

Although transurethral resection is often successful at relieving the infravesical obstruction, the untoward effects of valves on bladder function and the upper urinary tract may be irreversible. Intense and individualized care of bladder and renal function in boys with PUV is essential. Boys should be followed closely through adolescence because the bladder may change and late onset renal failure may occur (15).

Despite the ease of performing a vesical diversion and its effectiveness in relieving bladder outlet obstruction, controversy exists regarding both its necessity and ultimate effects on bladder function (5,7).

ANTERIOR URETHRAL VALVES

Anterior urethral valves occur 10 times less frequently than PUVs and may be located anywhere along the anterior urethra. In most cases, an anterior urethral valve is actually a congenital urethral diverticulum with the lip of the diverticulum preventing antegrade flow of urine. The bulging diverticulum may further obstruct the urethra by compressing the lumen. These children present with symptoms similar to those with a PUV, including varying degrees of hydroureteronephrosis; however, many also present with penile ballooning. As with PUV, the diagnosis is also made on VCUG. A renal ultrasound should be performed to complete the evaluation. Cystourethroscopy may miss the valve due to the retrograde flow of fluid during the procedure.

Although the obstruction is most commonly relieved endoscopically, a vesicostomy is a good temporizing procedure if the child is too small or too ill (20). Endoscopically, the distal lip is incised using a hook or right-angle wire electrode. If unsuccessful, the diverticulum may be excised and the urethra reconfigured in two layers over an 8Fr or 10Fr catheter using polydioxanone or polyglactin suture. A vascular dartos pedicle flap over the urethral repair may be useful to prevent fistula formation. Staged urethroplasty may be the best treatment option when faced with a large urethral diverticulum. Management of the hydroureteronephrosis would be similar to that in a patient with a PUV.

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CHAPTER 98 HYPOSPADIAS

LAURENCE S. BASKIN

Hypospadias is defined by the three major anatomical defects: (a) the abnormal location of the urethral meatus, (b) penile curvature, and (c) abnormalities of the foreskin. The objective in treating patients with hypospadias is to reconstruct a straight penis for normal coitus and place the new urethral meatus on the terminal aspect of the glans to allow a forward-directed stream. There are five basic steps for a successful hypospadias outcome: (a) orthoplasty (straightening), (b) urethroplasty, (c) meatoplasty and glanuloplasty, (d) scrotoplasty, and (e) skin coverage. These various elements of surgical technique can be applied either sequentially or in various combinations to achieve a surgical success (1,2).

DIAGNOSIS

Meatal Abnormalities

Hypospadias is characterized by an abnormality in location and configuration of the urethral meatus and surrounding urethral spongiosum (Fig. 98.1). The urethral meatus may be ventrally placed just below a blind dimple at the normal meatal opening on the glans or so far back in the perineum that it appears as a “vaginal” hypospadias. Most patients present with the urethral meatus on the glans penis, coronal margin, or distal aspect of the glans. The configuration of the meatus may vary in form, diameter, elasticity, and rigidity. It can be fissured in both transverse and longitudinal directions or can be covered with delicate skin secondary to associated atresia of the supporting urethral spongiosum. In the case of the megameatus intact prepuce, the distal urethra is enlarged, tapering to a normal caliber in the penile shaft. Often, there is an orifice of a periurethral duct located along the urethral plate distal to the meatus that courses dorsal to the urethral channel for a short distance. It is blind ending and does not communicate in any way with the urinary stream. The periurethral duct corresponds with Guérin sinus or Morgagni lacunae. Unless these ducts are inadvertently closed, leading to a blind ending epithelial pouch, they are of no clinical consequence.

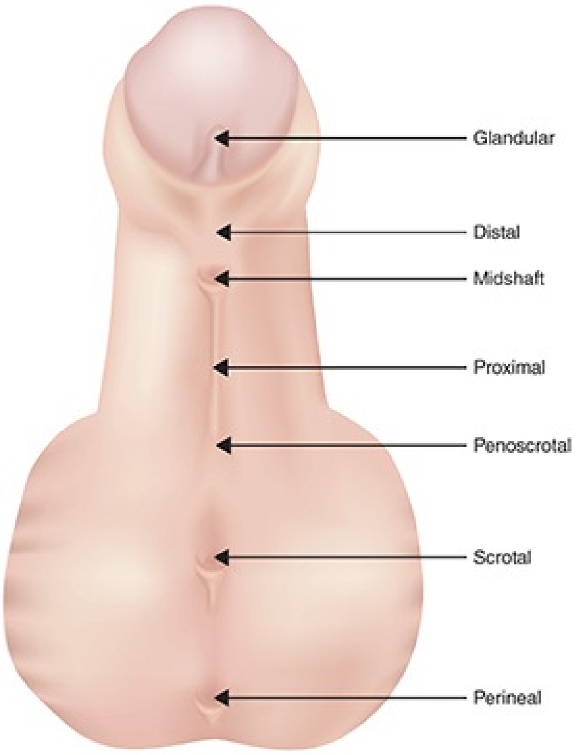

FIGURE 98.1 Location of the hypospadias meatus: glandular, distal, midshaft, proximal, penoscrotal, scrotal, and perineal.

Skin and Scrotal Abnormalities

The skin of the penis is changed as a result of the disturbance in the formation of the urethra. Prepuce formation is aborted distal to the abnormal meatus with excess dorsal foreskin. Proximal to the meatus, there is often a paucity of ventral skin, which may contribute to penile curvature. The frenulum is always absent in hypospadias. Vestiges of a frenulum are sometimes found inserting on either side of the open navicular fossa.

The skin proximal to the urethral meatus may be extremely thin, so much so that a catheter or probe passed proximally is readily apparent through a tissue paper thickness of skin.

The urethral plate defined as a rectangular segment of tissue from the abortive hypospadias urethral meatus to the glandular groove is often well developed. Even with a meatus quite proximal on the shaft, this normal urethral plate is quite elastic and typically nontethering. After degloving the penile shaft skin, artificial erection demonstrates no ventral curvature in these situations. A normal urethral plate may be incorporated into the surgical repair. However, in the rare severe case of hypospadias if the urethral plate is underdeveloped, it will act as a tethering fibrous band that bends the penis ventrally during artificial erection. When this fibrous chordee tissue is divided, the penile curvature will frequently improve.

Normally, the penis should develop in a cranial position above the two genital swellings. The penis may be caught between the two scrotal halves and become engulfed with fusion of the penoscrotal area resulting in penile scrotal transposition.

Penile Curvature

The curvature of the penis is caused by deficiency of the normal structures, most commonly on the ventral side of the penis. It has been labeled *chordee*; however, this term implies a strand of connective tissue stretched like a cord between the meatus and glans, which is rarely found in practice. Penile curvature can be from skin deficiency, a true fibrous chordee with tethering of the ventral shaft, or deficiency of the corpora cavernosa on the concave side of the penis (3).

There are occasional reports of other penile anomalies that represent variations of the embryologic defect causing hypospadias. They can be characterized as a defect in the course of the urethra such as congenital urethral fistula and a group characterized by curvature of the penis without hypospadias or so-called chordee without hypospadias.

SURGICAL TECHNIQUE

Hypospadias Surgeons

Success is directly related to the experience of the surgeon (4). For a successful result in hypospadias repair, the penile tissues must be handled with great care. Experience in mobilizing and rotating skin flaps is needed, as are the minutiae involved in plastic surgical techniques. It is not enough to review pictures and follow descriptions; training in the techniques is essential. Knowledge of a few methods is not enough because the one used must be the best for the individual situation of the child. A pediatric urology fellowship is the appropriate place to become competent in hypospadias surgery.

Preoperative Evaluation

Because hypospadias is typically an isolated anomaly, the entire genitourinary tract does not require evaluation. This assumes that the remainder of the physical exam is normal including a normally placed anus and no spine abnormalities. The absence of one gonad, perineal hypospadias, severe chordee, or a bifid scrotum suggests a disorder of sex development (DSD) and requires genotypic evaluation (5). If both gonads are not palpable, consider the possibility of congenital adrenal hyperplasia in a phenotypic female.

Age for Operation

Select a time between 6 and 9 months for surgery. At this age, the infants are also easiest to manage, are not walking, and remain in diapers. Babies appear to have less bladder spasms and require smaller doses of pain medication. They do not seem to remember the surgery as teenagers and adults.

The routine use of preoperative androgen stimulation is not indicated and remains controversial for patients with a small glans and penis that require an appropriate evaluation for a DSD (6). When considered indicated, testosterone may be administered to increase the size of the penis and especially the size and vascularity of the prepuce should it be needed for proximal and perineal hypospadias repair. A standard dose is 25 to 50 mg of testosterone enanthate in oil administered intramuscularly, repeated once or twice at 3-week intervals before operation.

Outpatient Repair

An uncomplicated hypospadias operation can be done without hospital admission. Preoperative education explaining the procedure, obtaining informed consent, answering the family's (and when age-appropriate, the patient's) questions, and reviewing the postoperative catheter care and pain management is the norm. Patient educational material has proved to be extremely helpful.

Nerve Block

A caudal nerve block placed by the anesthesia team is an excellent form of postoperative pain control. A good alternative is a penile nerve block. To place a penile nerve block in a healthy infant use 3 to 4 mL of 0.5% long-lasting bupivacaine mixed with 1% of quick-acting lidocaine. Inject it at the base of each crus just below the notch of the symphysis, or vertically in the midline deep to the notch of the symphysis and around the ventral aspect of the base of the penis, with a 1 1/2-inch 25-gauge needle. When placed at the beginning of an operation, it will reduce the amount of general anesthesia required and will provide anesthesia that will last well into the postoperative period.

Surgical Hints

Hemostasis

For hemostasis, use 1% lidocaine with 1:100,000 epinephrine and inject it through a 27- to 29-gauge needle within the glans and the area of abortive spongiosum. Wait 7 minutes for it to act. This vasoconstrictor will reduce the bleeding during the dissection, but if the operation is prolonged beyond 90 minutes, rebound vasodilation can be expected. Avoid electrocoagulation as much as possible; if it is necessary, use a bipolar cautery or touch a monopolar cautery to only the forceps unit set at a low current. Once the glans flaps are applied, bleeding improves, and a pressure dressing will usually assure hemostasis. On rare occasion, use of tourniquet that is typically used for artificial erections can facilitate hemostasis.

Artificial Erection

To induce a saline-induced erection, place a sterile rubber band or vascular loop around the base of the penis and snug it with a hemostat. Introduce a 25-gauge butterfly needle into the corpus cavernosum. Gently distend the penis with injectable normal saline solution; avoid overdistention. Maintain the erection during evaluation of the penile curvature. After the curvature has been corrected, create a second erection to check penile alignment.

Local Urinary Diversion in Children

Diversion of urine away from the suture lines has always been a problem in children because any indwelling tube, particularly one terminating in a balloon, induces bladder spasms that force urine around it into the repair. This disrupts the suture line and leads to formation of fistulas. Besides, the lumen of a balloon catheter is small compared to that of a straight catheter, especially a plastic one.

Many techniques have been tried to minimize these problems with diversion. The simplest method for infants, one that combines stenting with drainage, is to insert a fine silicone tube, such as 6Fr peritoneal shunt tubing or neurosurgical tubing with its wand-like end, into the bladder through the urethra and fasten the end to the glans in one or two places with nonabsorbable sutures.

Alternately, place a 6Fr Kendall catheter of soft Silastic, with a Luer-lock at the end to prevent internal migration and to allow irrigation. Whatever intubation system is used in infants, collect the urine in a double diaper. For older boys, use a feeding tube, or in teenagers, a urethral balloon catheter; tape it to the abdomen so that it cannot disturb the ventral glans repair. Drainage should be continued for 4 to 7 days for distal and penile shaft repairs and 7 to 10 days more severe hypospadias repairs.

Dressings

Apply a dressing to immobilize the area, to reduce edema, and to prevent the formation of a hematoma. Use transparent and permeable absorbent plastic film (Tegaderm or OpSite) applied over Telfa or tincture of benzoin. Let the catheter drain into an outer diaper. The dressing may be removed in 2 to 3 days after a few warm baths at home. Once the dressing has been removed, use K-Y jelly on the diaper to keep the repaired penis from sticking, typically for 4 to 5 days.

Setup for Operation

Instruments

Select instruments designed for delicate handling of tissues. A reasonable list would include loupe magnification, genitourinary fine and microsurgery sets, microsurgical knife (Weck), toothed and nontoothed forceps (Adson), fine Allis clamps, fine clamps, two pairs of Bishop–Harmon forceps or 0.5 platform forceps, sharp small tenotomy scissors, iris scissors, microtip Castroviejo scissors, microtip Castroviejo needle holders, plastic needle holders and ring retractor (Scott/LoneStar), and hooks. Also, have available bougie à boule, 5Fr and 8Fr infant feeding tubes, rubber bands, a marking pen, a 25-gauge butterfly needle and syringe, and a handheld Bovie, or an ophthalmic electrocautery. Have fine sutures of appropriate sizes and types at hand but unopened—for example, 5-0 Prolene on a C-1 tapered needle for glans traction, 7-0 polydioxanone suture (PDS) and Vicryl for urethroplasty, and 6-0 PDS for the skin.

Selection of the Operative Technique

Figure 98.2 presents an algorithm for the reconstruction of hypospadias. A tried and true approach is to start each repair by preserving the urethral plate, dissecting the skin to the penile scrotal junction, and assessing for the presence of penile curvature. If curvature is not present or mild to moderate and amendable to dorsal plications, then a one-stage approach is typically successful. The specific repair is now dependent of the meatal configuration and the surgeon’s preference (1).

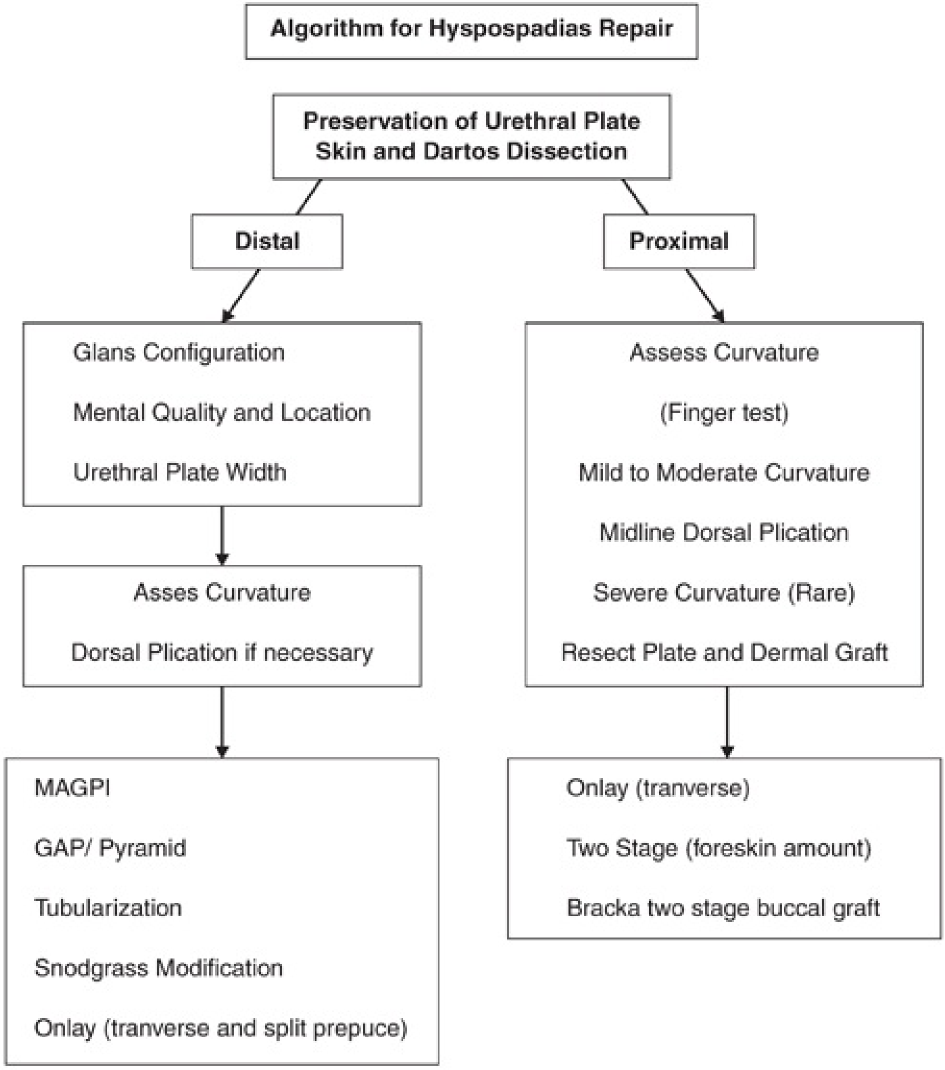
Algorithm for Hyspospadias Repair
Preservation of Urethral Plate
Skin and Dartos Dissection
Distal
Proximal
Glans Configuration
Mental Quality and Location
Urethral Plate Width
Asses Curvature
Dorsal Plication if necessary
MAGPI
GAP/ Pyramid
Tubularization
Snodgrass Modification
Onlay (tranverse and split prepuce)
Assess Curvature
(Finger test)
Mild to Moderate Curvature
Midline Dorsal Plication
Severe Curvature (Rare)
Resect Plate and Dermal Graft
Onlay (tranverse)
Two Stage (foreskin amount)
Bracka two stage buccal graft

FIGURE 98.2 Algorithm for hypospadias repair.

Treatment of Anterior Hypospadias

The Meatal Advancement and Glanuloplasty Technique

The hypospadiac penis that is amenable to the meatal advancement and glanuloplasty (MAGPI) is characterized by a dorsal web of tissue within the glans that deflects the urine from either a coronal or a slightly subcoronal meatus (7). Once the patient is asleep, the urethra itself must have a normal ventral wall, without any thin or atretic urethral spongiosum. The urethra also must be mobile so it can be advanced into the glans (Fig. 98.3).

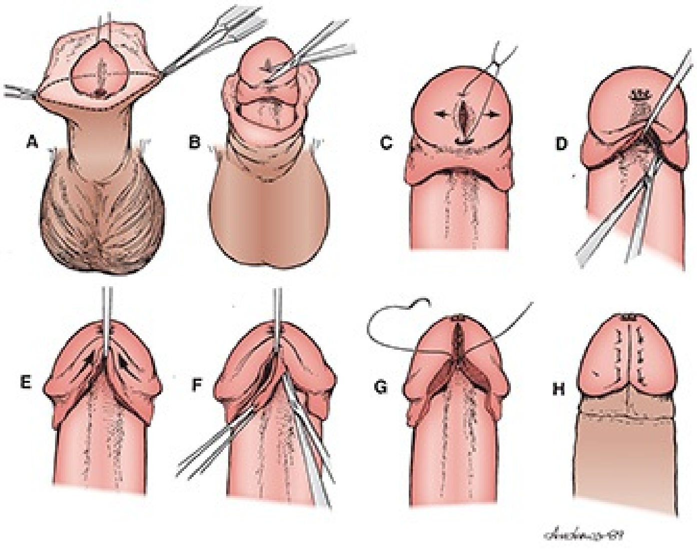

FIGURE 98.3 MAGPI procedure. Note the proximal location of the initial circumcising incision (*dotted line*) in relation to the urethral meatus (**A**). The dorsal meatotomy is as shown (**B** and **C**) (vertical incision closed horizontally). The glans is then detached from the lateral margin of the corpus spongiosum and the side of the corpora cavernosa (**D**). The edge of the glans on either side that will be approximated ventrally is identified (*arrows*) (**E**). The triangle of skin between these two points and the urethral meatus is excised completely (**F**). Dissection must stay right on the skin because the urethra here is usually thin and easily entered. Excising this skin allows exposure of the glans tissue which can now be reapproximated into a conical shape to complete reconstruction with the meatus in a terminal position (**G** and **H**).

The Glans Approximation Procedure

The glans approximation procedure (GAP) is applicable in a small subset of patients with anterior hypospadias who have a wide and deep glandular groove (8). These patients do not have a bridge of glandular tissue that typically deflects the urinary stream, as seen in patients who would be more appropriately treated with the MAGPI procedure. In the GAP procedure, the wide-mouth urethra is tubularized primarily, over a stent (Fig. 98.4). Ventral glandular tilt, meatal retraction, and splaying of the urinary stream can result from the inappropriate use of the MAGPI technique in these circumstances.

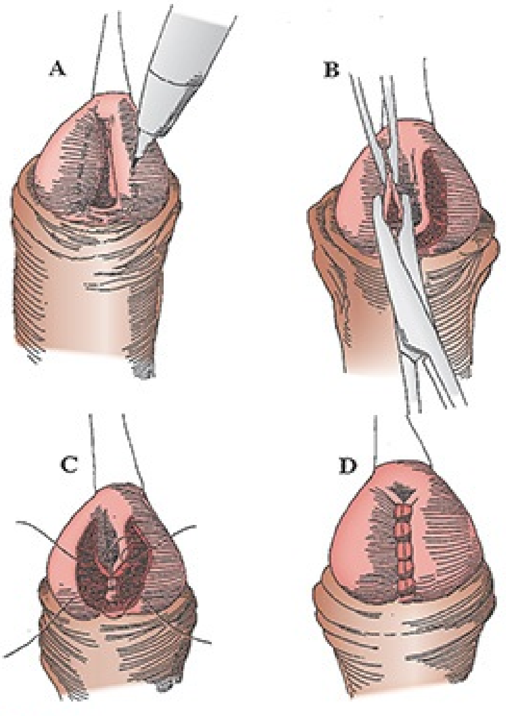

FIGURE 98.4 GAP hypospadias technique. **A:** Initial incision. **B:** Exposure of the glans mesenchyme by de-epithelialization of tissue, which is critical for a two-layer glans closure, allowing for good support of the urethroplasty. **C:** Tubularization of the neourethra, followed by glans closure. **D:** The completed repair. (Reproduced with permission from Grossfeld J, O'Neill J, Coran A, et al. *Pediatric Surgery*, 6th ed. Philadelphia: Elsevier, 2006. Copyright 2006 Elsevier.)

The Urethral Plate

Duckett has popularized the concept of preservation of the urethral plate, which is now standard practice for anterior as well as more severe posterior hypospadias surgery (9,10). The urethral plate serves as the dorsal urethral wall, and the ventral urethra is created by a vascular onlay flap of tissue from the inner prepuce. Extensive experience has shown that the urethral plate is rarely the cause of penile curvature. The concept of preserving the urethral plate yet undermining the plate and exposing the corporal bodies with the idea that chordee tissue could be released has not held true. In fact, careful anatomic studies have shown an extensive network of blood vessels supplying the urethral plate in the hypospadiac penis and lifting of the urethral plate defeats the purpose of preservation by violating this intricate blood supply (11).

Thiersch-Duplay or Primary Tubularization

Thiersch-Duplay or primary tubularization is applicable to patients with a wide urethral plate with mild to moderate amounts of penile curvature (12) (Fig. 98.5). The key concept of the operation is healthy urethral plate that can be primarily tubularized without compromising the glansplasty. In babies, the width of the plate should be a minimum of 11 mm. The urethroplasty is closed with either an interrupted or subcuticular fine suture. If abortive spongiosum is available, adjacent to the urethroplasty this can be incorporated as a second layer. An additional layer of coverage is provided by a de-epithelialized pedicle flap based on blood supply of the dorsal prepuce (see the following text). The flap can be buttonholed or wrapped around either side of the penis to cover the urethroplasty. Mobilizing the glans wings to 90 degrees in respect to the urethral plate allows a tension-free two-layer glansplasty.

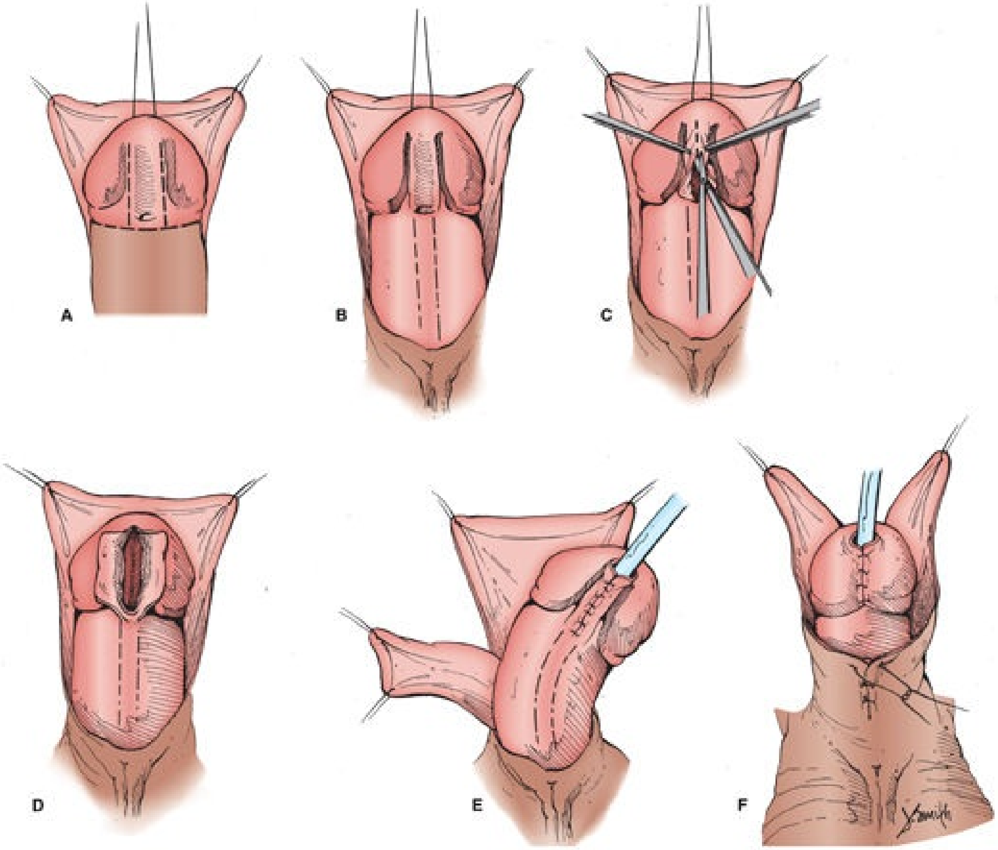

FIGURE 98.5 Thiersch-Duplay or primary tubularization with Snodgrass modification (Tubularized, incised plate [TIP] urethroplasty). **A:** *Horizontal line* indicates circumscribing incision to deglove penis. *Vertical lines* show junction of urethral plate and ventral glans. **B:** Parallel incisions separate urethral plate from glans. If the urethral plate is narrow, then an incision in the urethral plate allows for primary tubularization (Snodgrass modification). **C:** Midline incision of urethral plate from meatus to granular tip. **D:** Incision has widened and deepened the urethral plate. **E:** Plate tubularized over 6Fr stent. Dorsal subcutaneous tissues are rotated ventrally to cover the repair (de-epithelialized pedicle flap). **F:** Midline closure of glans wing, mucosa collar, and ventral shaft skin.

Tubularized Incised Plate Urethroplasty (Snodgrass Modification)

Historically, if the urethral groove was not wide enough for primary tubularization, then an alternative approach such as the Mathieu (perimeatal based random flap) or, for more severe hypospadias, a vascularized pedicle flap was performed. Recently, the concept of the incision in the urethral plate with subsequent tubularization and secondary healing has been introduced by Snodgrass (13) (Fig. 98.5D and E). Short-term results have been excellent, and this procedure is enjoying extensive popularity. More recently, this technique has been applied to more posterior forms of hypospadias. Theoretically, there is concern about the possibility of meatal stenosis from scarring as occurs in patients with urethral stricture disease where direct vision internal urethrotomy often leads to recurrent stricture. However, reports of meatal stenosis have been relatively rare. In hypospadias, the native virgin tissue with excellent blood supply and large vascular sinuses seems to respond to primary incision and secondary healing without scar. The tubularized incised plate urethroplasty is also conducive to preservation of the foreskin (14). To preserve the foreskin, the incision is made only on the ventrum; therefore, patients with significant penile curvature are not candidates for this procedure. A three-layer closure of the prepuce prevents foreskin fistulas. The fact that the foreskin cannot be used as a de-epithelialized flap theoretically increases the chance for urethra fistula.

Dorsal Onlay Flap

The blood supply to the hypospadiac preputial tissue is reliable. The abundance of cutaneous tissue on the dorsum of the penis is vascularized in a longitudinal fashion. This tissue may be dissected from the penile skin, creating an island flap from the inner layer of the prepuce. The transverse onlay flap is prepared by placing four holding on the dorsal prepuce to define a rectangular transverse flap (Fig. 98.6B). The flap is dissected by first separating just the skin of the proximal aspect of the rectangle. The onlay flap and its blood supply are then separated from the dorsal penile skin by dissecting as close as possible to the dermis. The penile skin will survive on its intrinsic blood supply and the flap on the vascular pedicle to the prepuce.

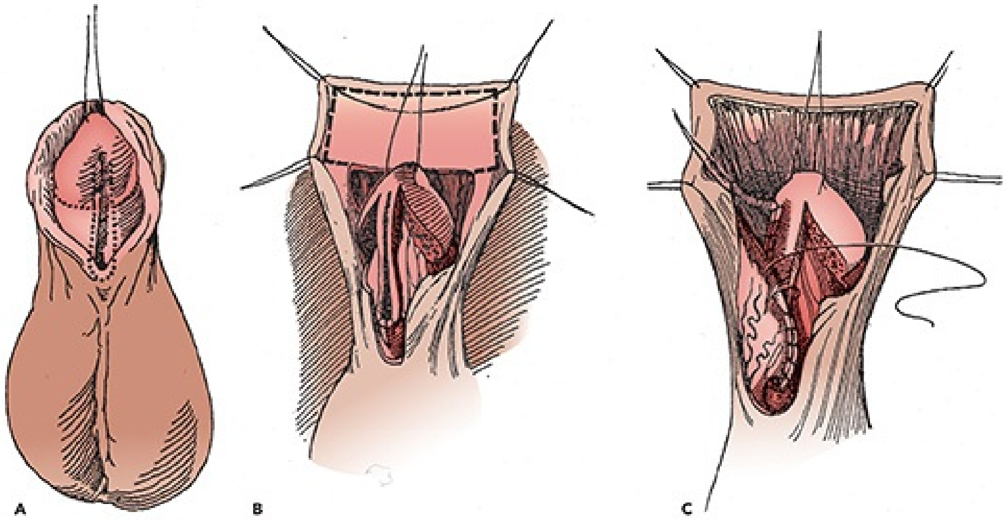

FIGURE 98.6 Transverse onlay island flap. A: Penile hypospadias. (Incision along *broken line*) B: Preservation of the urethral plate and *rectangular outline* of the onlay flap. C: Onlay of preputial island flap onto urethral plate.

For midshaft and distal shaft repairs, the flap may be created by splitting the prepuce in half, as described by Rushton and Belman (12). The inner foreskin flap of one side is used for the onlay and the outer foreskin of the same Byars flap is de-epithelialized for a vascularized layer of secondary coverage as described. (Fig. 98.7) (see the following text).

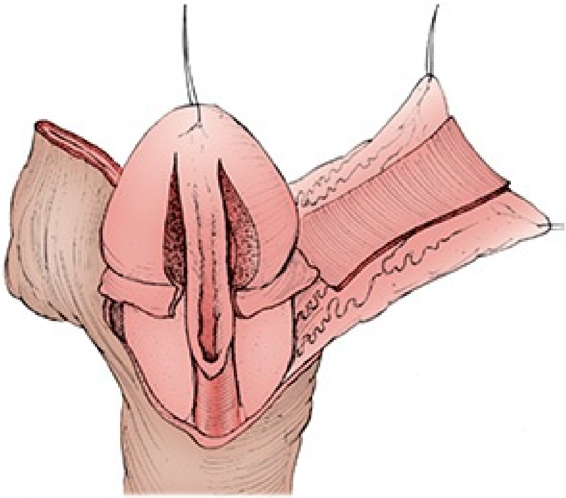

FIGURE 98.7 The prepuce is split vertically parallel to the blood supply to create both an onlay flap and secondary de-epithelialized urethroplasty coverage from one Byars flap.

Treatment of Posterior Hypospadias

Presently, in the majority of posterior hypospadias, including some perineal hypospadias, the urethral plate can be preserved and a vascularized flap used in an onlay fashion. In the rare case when the urethral plate needs to be resected, a two-stage technique can be employed (see the following text).

Onlay Island Flap

For posterior hypospadias (and anterior hypospadias with a thin urethral plate), all cases are approached by initially leaving the urethral plate intact. This includes patients with and without penile curvature. This technique can be applied to penile shaft as well as scrotal and perineal hypospadias. The intact dorsal plate essentially avoids complications of proximal stricture, and the excellent blood supply has decreased the fistula rate to approximately 5% to 10% for all cases of transverse onlay island flap hypospadias repair (see Fig. 98.6) (9,15). The onlay flap is appropriately trimmed and sutured to the urethral plate creating the new urethral. Long-term results with the onlay island flap have been very durable. For very severe hypospadias, the prepuce can be designed as a horseshoe style to bridge extensive gaps.

The Split Prepuce In Situ Onlay Hypospadias Repair

A modification of the onlay technique which can be applied to both anterior and midshaft hypospadias is to split prepuce in situ onlay. As described, in this procedure, the prepuce is split vertically, parallel to the blood supply to create both an onlay flap and secondary de-epithelialized urethroplasty coverage (16) (see Fig. 98.7). Long-term results have withstood the test of time with minimal complications.

Two-Stage Hypospadias Repair

An alternative approach for severe hypospadias is to transfer the dorsal prepuce to the ventrum after correction of penile curvature (Fig. 98.8). In severe cases, the urethral plate may need to be resected to correct penile curvature. Dermal grafting may be required, and performing an urethroplasty on top of the healing graft is not suggested. Byars flaps can be rotated from the dorsum setting up ventral coverage for subsequent urethroplasty (17). The second stage is performed at least 6 months after the first stage. To facilitate the urethroplasty within the glans, during the first stage, dorsal skin is tucked within the glans wings. Subcutaneous secondary coverage of the reconstructed urethra is performed to prevent fistula.

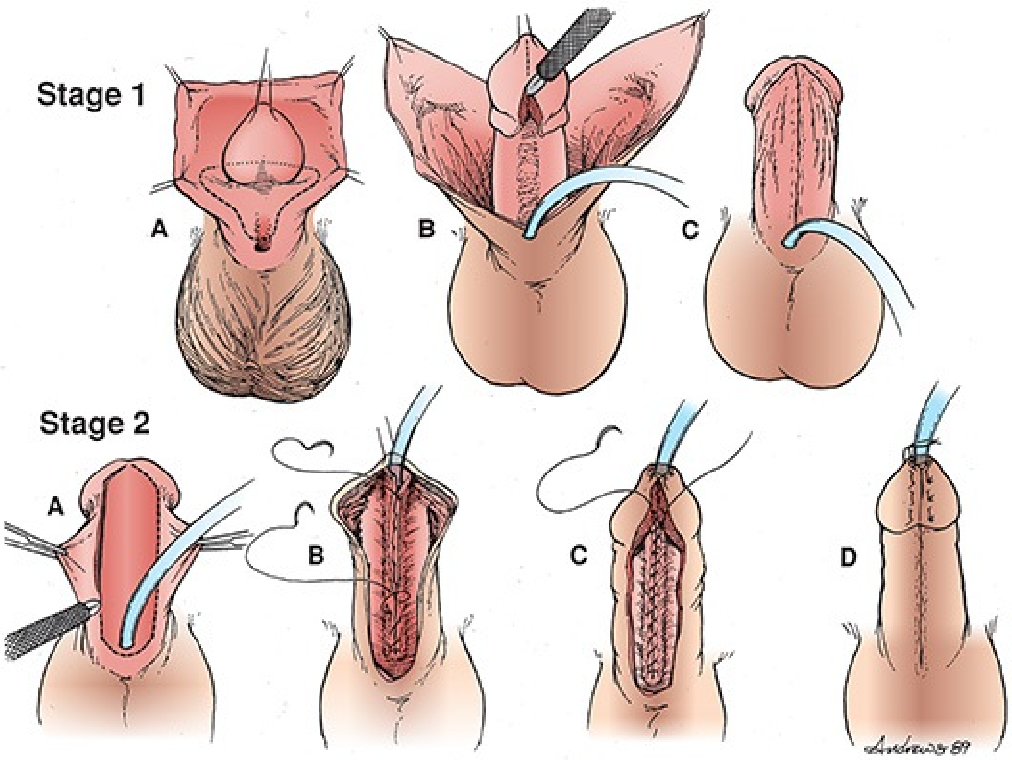

FIGURE 98.8 Two-stage repair. Stage 1: The penis is degloved (incision along *broken line*), the urethral plate resected, and the curvature corrected (A). The unfolded foreskin is brought out to the tip of the incised and mobilized glandular wings (B). Delicate sutures reapproximate the skin in the midline and fix the skin to the corpora cavernosa (C). Stage 2: A sufficient strip of skin is outlined that will form the urethra (A). Dissection of the shaft skin is lateral and away from the neourethra (Incision along *broken line*). Two layers of inverting sutures are used to close the neourethra (B). If the prepuce has been positioned sufficiently distal at the first stage, a normally positioned meatus with good ventral glandular support can be achieved (C). Any excess shaft skin is excised, but the dartos layer is preserved (de-epithelialization) to drape across the neourethral suture line (D).

Bracka Buccal Two-Stage Repair

For patients with prior surgery or with severe hypospadias, Bracka (18) has described a buccal free graft two-stage repair. In the first stage, the penis is straightened and the scarred urethra is discarded (Fig. 98.9). Buccal mucosa is harvested from either the cheek or lip and grafted to the prepared bed (19). Extensive quilting of the graft is performed to prevent hematoma from lifting off the buccal mucosa. During the first stage, glans wings are mobilized in preparation for the creation of a slit-like meatus during the second stage. The second-stage urethroplasty is undertaken at least 6 months after the first stage. In the second stage, excess buccal is trimmed off the glans setting up a two-layer glans closure. The buccal mucosa is rolled into the new urethra and subcutaneous tissue is used for secondary coverage.

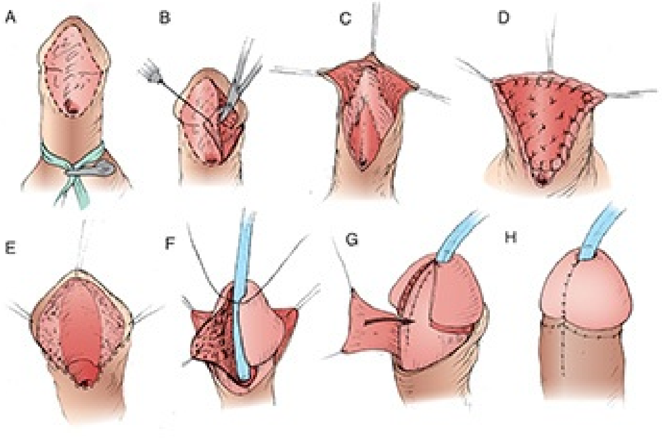

FIGURE 98.9 Schematic two-stage Bracka buccal hypospadias repair. **A–D:** First stage. **A:** Patient with a midshaft hypospadias and a paucity of available skin after multiple previous hypospadias repairs (incision along *broken line*). **B:** Resection of scar tissue. **C:** Mobilization of glans wings. **D:** Buccal free graft quilted into the resected scar. **E–H:** Second stage after 6 months of healing. **E:** Exposure of glans mesenchyme and trimming of buccal graft for subsequent urethroplasty. **F:** Urethroplasty. **G:** Secondary de-epithelialized pedicle coverage (*arrow*) of the urethroplasty. **H:** Two-layer glansplasty and completed repair. (Reproduced with permission from Grossfeld J, O'Neill J, Coran A, et al. *Pediatric Surgery*, 6th ed. Philadelphia: Elsevier, 2006. Copyright 2006 Elsevier.).

Penile Curvature (Chordee)

Correction of penile curvature has also evolved along with the concept of preservation of the urethral plate. Based on anatomic studies of the human fetal penis, a simpler approach of placing dorsal midline plication sutures in the nerve free zone at 12 o’clock is now advocated (11). The midline dorsal plication avoids the need for mobilization of the neurovascular bundle (Fig. 98.10). The midline plication can be applied to mild and moderate to severe degrees of curvature. If more than two rows of plication sutures or greater than four permanent sutures are necessary, then an alternative approach such as complete resection of the urethral plate and dermal grafting should be considered. During artificial erection, if the chordee cannot be corrected with your “finger,” the midline dorsal plication is not advised.

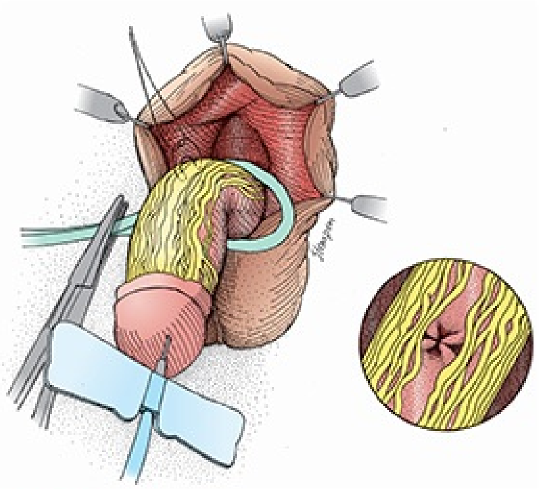

FIGURE 98.10 Midline dorsal plication technique. In this technique, plication sutures are placed in the tunica albuginea in the 12 o’clock position, which is free of both nerves and vascular structures (inset). This technique involves a minimum amount of manipulation to the penis. It is not necessary to incise into the corporeal body or extensively mobilize the fascia of Buck. A maximum of two rows of parallel plications at the 12 o’clock position can be placed for correction.

Postoperative Problems

Bladder spasms not only cause the child to move about in response to pain but also force urine through the repair. Proper pain control with operative nerve blocks and postoperative analgesics and antispasmodics, such as oxybutynin (Ditropan), is recommended. Narcotics and antispasmodic regimen may result in constipation leading to straining and urine leakage and can be prevented with a proper diet, adequate fluid intact, and occasional stool softeners and/or laxatives.

Bleeding is an infrequent problem. A compressive sandwich dressing will resolve the problem in all but the rare patient. In selected cases, give a broad-spectrum antibiotic such as trimethoprim (Septra) or a cephalosporin and continue it for a few days after the tubing has been removed.

Standard follow-up is to see the patient at the time of catheter removal, 6 weeks and 1 year after the repair. Reevaluate after potty training and at puberty to confirm patient satisfaction and the absence of fistula, stenosis, diverticulum, recurrent chordee, and cosmetic issues.

OUTCOMES

Results today cosmetically and functionally are better than those in the past. The use of a one-stage hypospadias repair at an early age with low complication rate encourages our current positive outlook for this condition. Curvature correction with the aid of an artificial erection is important for assuring satisfactory sexual function. With the placement of the urinary meatus at the tip of the glans, the infertility potential has been improved unless the patient has other coexisting testicular problems.

Evidence shows that the neourethra grows with the child, and subsequent repairs are seldom necessary.

Early hypospadias repair with minimal hospitalization helps to avoid separation anxiety and patient awareness of the procedure. We can now counsel parents confidently that there is an excellent outlook for a good cosmetic, functional, and emotional result in boys with all degrees of hypospadias.

Complications

Complications occur after 10% to 40% of hypospadias operations. These include meatal retraction, urethrocutaneous fistula formation, meatal stenosis, urethral stricture, development of a diverticulum (sometimes with hair, followed by stones), and persistent penile curvature. Of these, strictures, fistulas, and urethral diverticula account for most of the late problems. Manage these complications at least 6 months from the time of the initial surgery.

PRACTICAL CONCLUSIONS

1. Hypospadias should be repaired within the first year of life, preferable at 6 to 9 months of age. Pain control and catheters seem better tolerated and the baby's lack of mobility simplifies postoperative care.
2. A terminal slit-like meatus should be the goal with or without preservation of the foreskin depending on parental preference for all but the most severe forms of hypospadias.
3. Preservation of the urethral plate creates the best possible chance to recreate normal urethral anatomy by incorporating the abortive spongiosum to support the urethroplasty into the repair.
4. Midline dorsal plication is safe and effective for the correction of penile curvature in the majority of patients (placing more than two rows of sutures is a sign that another technique such as dermal grafting is indicated).
5. In the small percentage of patients who require resection of the urethral plate, a two-stage approach is generally warranted.
6. Vascularized pedicle onlay flaps are successful in primary and redo hypospadias surgery.
7. De-epithelialized vascular flaps should be used as a second layer for all urethroplasties.
8. Patients with a paucity of skin are best managed with the Bracka two-stage buccal repair.
9. Coronal fistulas require a redo glansplasty.
10. Surgical volume correlates with successful outcomes.

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CHAPTER 99 COMPLETE PRIMARY REPAIR FOR EXSTROPHY

RICHARD W. GRADY

Bladder exstrophy is a congenital anomaly that has consistent external physical manifestations; the diagnosis of exstrophy is usually made immediately after birth, although it can be detected antenatally. The anterior portion of the bladder and/or urethra and abdominal wall structures are deficient, and the pubic symphysis is widely diastatic (Fig. 99.1); the bladder and urethra are herniated ventrally. The exstrophic defects are typically found in isolation; other organ systems are only infrequently affected with classic bladder exstrophy and epispadias. However, children with exstrophy typically have an anteriorly located anus. Female genital anatomy is altered, with a more vertically oriented vaginal opening after closure and a wider and shorter vagina than normal. The anterior component of the penis is also foreshortened in males compared to the general population.

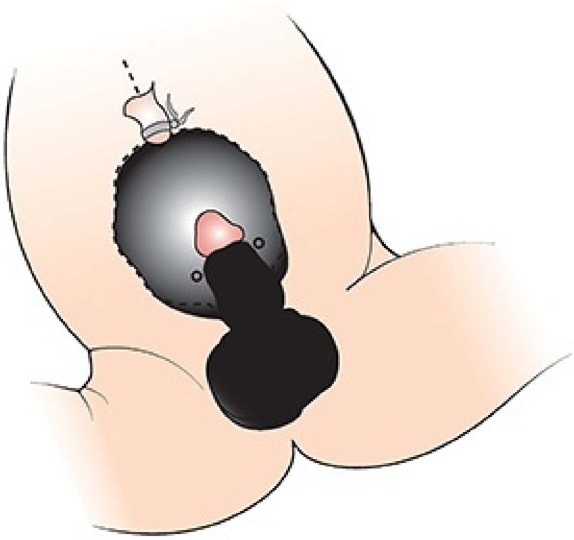

FIGURE 99.1 Initial dissection, inferior view. *Dashed lines* indicate lines of dissection. Note that the lines of dissection proceed around the umbilicus and superior to it. The line of dissection also extends subcoronally around the ventral aspect of the penis. See Figure 99.2 for another view of the initial lines of dissection.

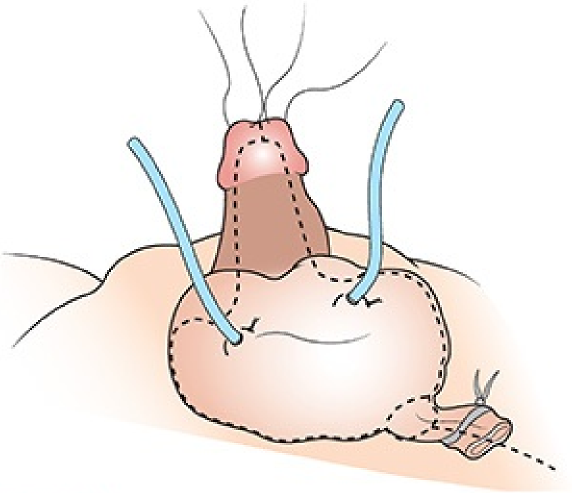

FIGURE 99.2 View of lines of dissection from Figure 99.1. The urethral dissection is carried along the lateral aspect of the urethral plate.

DIAGNOSIS

In some situations, the diagnosis may be made antenatally, although many affected fetuses are not detected before birth (1). In Gearhart's et al.'s review of 29 antenatal studies of 17 children born with exstrophy, only 3 were identified before delivery despite the presence of findings to suggest the diagnosis. Ultrasonography can reliably detect exstrophy before the 20th week of gestation (2,3). Ultrasonographic absence of the bladder is a hallmark of exstrophy. Other findings include a semisolid mass protruding from the abdominal wall, a lower abdominal protrusion, an anteriorly displaced scrotum with a small phallus in male fetuses, normal kidneys in association with a low-set umbilical cord, and an abnormal iliac crest widening.

Subtle findings such as low umbilical cord insertion and the location of the genitalia can be seen but only if the fetus is examined in a sagittal alignment with the spine (2). Because exstrophy affects the external genitalia, the diagnosis is easier to make in males than in females. Iliac crest widening can also be seen during the routine prenatal evaluation of the lumbosacral spine that is performed to evaluate for myelomeningocele. The iliac angle will be about 99 degrees rather than the 90 degrees that is normally seen. Because urine production is not affected for these fetuses, amniotic fluid levels should be normal.

Prenatal diagnosis allows optimal perinatal management of these infants. The infants can be delivered near a pediatric center equipped to treat babies with this unusual anomaly. Of equal importance, antenatal diagnosis also allows the parents the opportunity to discuss early management of the patient, which we recommend include the expertise of a pediatric urologist experienced in the treatment of bladder exstrophy. Patients with exstrophy can have a satisfactory long-term outcome and life expectancy with appropriate management.

INDICATIONS FOR SURGERY

Exstrophy anomalies are nonlethal in the developed world; children with exstrophy can survive untreated into adulthood (4). However, significant morbidity exists with these conditions if they are left untreated, including total urinary incontinence, bladder and kidney infections, skin breakdown, and tumor formation in the bladder plate. The surrounding skin around the exposed exstrophic bladder is often inflamed secondary to urine contact dermatitis, loss of skin integrity from constant wetness, and secondary infection. In contrast, when these patients receive effective surgical and medical treatment, they can lead productive, healthy lives with minimal morbidity from their underlying urologic abnormality.

SURGICAL TECHNIQUE

Primary goals for exstrophy reconstruction include the following:

1. Urinary continence with volitional voiding
2. Preservation of kidney function with low-pressure urinary storage
3. Functional and cosmetically acceptable external genitalia

Secondary goals for reconstruction include the following:

1. Minimization of urinary tract infections
2. Effective abdominal wall and pelvic floor support
3. Minimization of the risk for malignancy associated with the urinary tract
4. Minimization of the risk for urinary calculi

Surgical reconstruction of exstrophy and epispadias represents one of the most significant challenges for physicians who specialize in the urologic care of children. In the late 1980s, Mitchell devised an anatomic approach that integrated epispadias and exstrophy repair. This operation evolved out of a technique developed for the treatment of epispadias—the complete penile disassembly technique and was inspired by the published experience of Dr. Julian Ansell who employed neonatal reconstruction for these children (5). By employing this technique, the surgeon permits the tissue deformation in exstrophy to return more closely to an anatomically normal position. We have used this approach to surgically treat newborns with exstrophy since 1990. The principles of this operation can be employed in some reoperative repairs or delayed repairs for exstrophy.

Preoperative Care

After delivery, to reduce trauma to the bladder plate, the umbilical cord should be ligated with a zero suture rather than a plastic or metal clamp. A hydrated gel or occlusive dressing may be used to protect the exposed bladder from superficial trauma. These types of dressing are easy to use, keep the bladder plate from becoming desiccated, and stay in place to allow handling of the infant with minimal risk of trauma to the bladder. Plastic wrap is an acceptable alternative. Dressings should be replaced daily, and the bladder should be irrigated with normal saline with each diaper change. A humidified air incubator may also minimize bladder trauma.

We routinely use intravenous antibiotic therapy in the pre- and postoperative period to decrease the risk for infection following reconstruction. This is critical to the success of the immediate postoperative repair. We also perform preoperative ultrasonography to assess the kidneys and to establish a baseline examination for later ultrasonographic studies. Preoperative spinal sonographic examination should be considered if sacral dimpling or other signs of spina bifida occulta are noted on physical examination.

Operative Considerations

The primary exstrophy closure is typically performed in the neonatal period and as early as 1 to 2 days after birth. We routinely use general inhalation anesthesia. However, nitrous oxide should be avoided during primary closure as it may cause bowel distention, which decreases surgical exposure during the operation and increases the risk of wound dehiscence. Some advocate the use of nasogastric tube drainage to decrease abdominal distention in the postoperative period, but we do not routinely use it postoperatively. We do routinely place an epidural catheter to reduce the inhaled anesthetic requirement during the operation. Tunneling the catheter may reduce the risk for infection if it is left in for prolonged periods after surgery.

For patients older than 2 to 3 days or newborns with a wide pubic diastasis, we perform anterior iliac osteotomies at the time of the exstrophy repair to decrease the tension on the wound closure. Osteotomies assist closure and enhance anterior pelvic floor support, which may improve later urinary continence.

Factors that appear to be important in the operative period include use of osteotomies in selected cases and for newborn closures >48 hours after birth to decrease the tension on the repair, ureteral stenting and bladder drainage catheters placed intraoperatively for use in the postoperative period to divert urine, avoidance of abdominal distention, and use of intraoperative antibiotics.

Complete Primary Repair for Exstrophy Surgical Technique: Boys

After standard preparation of the surgical field, we place transversely oriented traction sutures into each of the hemiglans of the penis. We then mark the lines of dissection (Figs. 99.1 and 99.2). Care is taken in marking these lines to exclude dysplastic tissue at the edges of the exstrophic bladder and bladder neck. This is particularly important at the bladder neck, where dysplastic tissue left in continuity may impair later bladder neck function. Following this, we place 3.5Fr to 5Fr catheters into both ureters and suture them in place with 5.0 chromic suture. Bladder polyps are removed prior to beginning the dissection, since these will occupy space after the bladder is reconstructed (see Fig. 99.2). Initial dissection begins superiorly and proceeds inferiorly to separate the bladder from the adjacent skin and fascia, since it is usually easiest to identify tissue planes in this location. We use tungsten fine-tip electrocautery (Colorado tip) during this dissection to reduce blood loss. The umbilical vessels may be ligated if necessary. We also incise the periumbilical skin circumferentially at this time. The umbilicus will be moved superiorly to a more anatomically normal location and will be later used as the location to bring out the suprapubic catheter (Figs. 99.3 and 99.4).

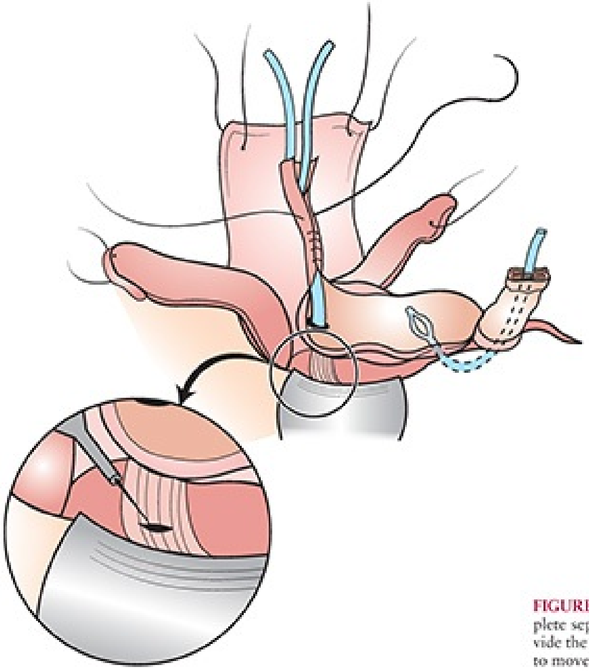

FIGURE 99.3 The exposure for deep dissection is optimal after complete separation of the corporal bodies. It is crucial to adequately divide the intersymphyseal band (*inset*) to allow the bladder and urethra to move posteriorly.

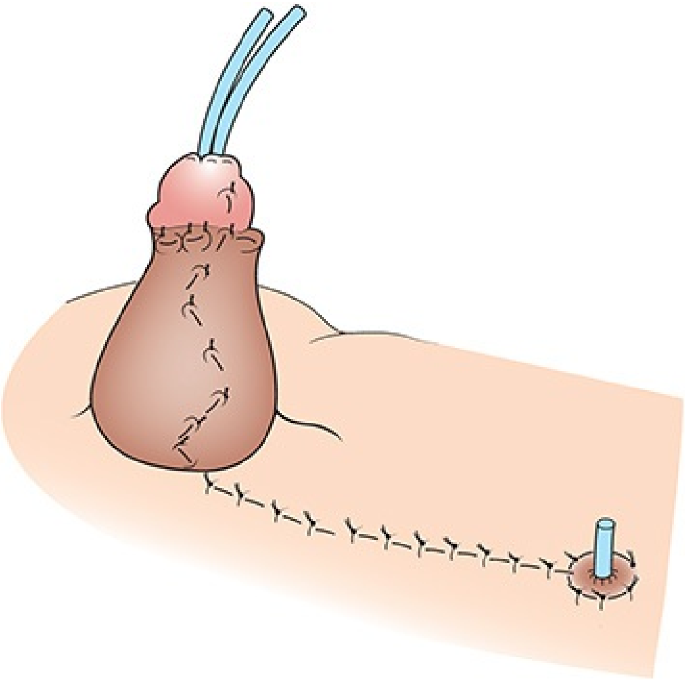

FIGURE 99.4 To adequately cover the penis dorsally, Z-plasty incisions may be necessary. We also employ tacking sutures dorsally.

Penile/Urethral Dissection

Traction sutures placed into each hemiglans of the penis aid in dissection at this point in the operation (see Fig. 99.2). The sutures will rotate to a parallel vertical orientation (Fig. 99.5) because the corporal bodies will naturally rotate medially after they are separated from the urethral wedge (urethral plate plus underlying corpora spongiosa). We begin the penile dissection along the ventral aspect of the penis as a circumcising incision (see line of dissection in Fig. 99.1). This step precedes dissection of the urethral wedge from the corporal bodies because it is easier to identify the plane of dissection above the Buck fascia ventrally (Fig. 99.6). The Buck fascia is deficient or absent around the corpus spongiosum; as the dissection progresses medially to separate the urethra from the corpora cavernosa, the plane shifts subtly from above the Buck fascia to just above the tunica albuginea. It is important to recognize this. Failure to adjust the plane of dissection will carry the dissection into the corpus spongiosum; this will result in excessive, difficult-to-control bleeding during the deep ventral dissection of the urethral wedge from the corporal bodies.

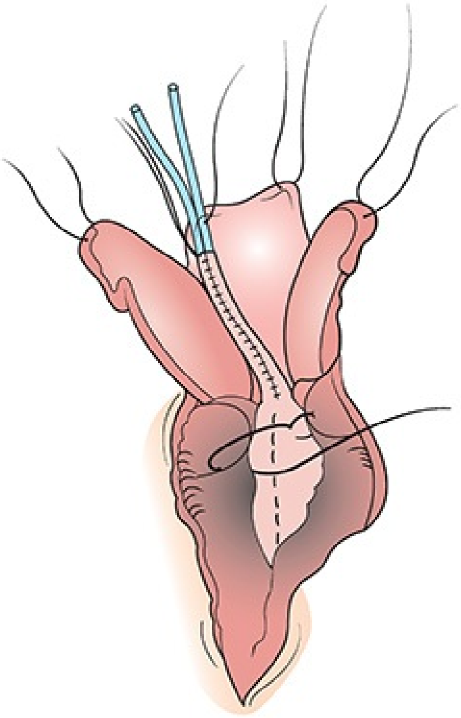

FIGURE 99.5 The urethra and bladder are reapproximated in a two-layer closure.

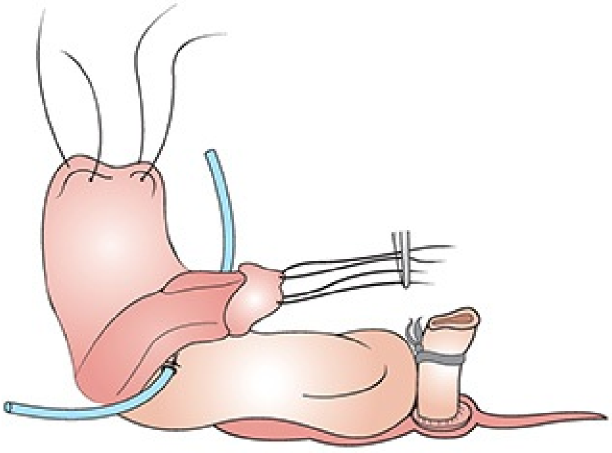

FIGURE 99.6 Ventral dissection is initiated most easily below the glans with a circumcising incision. The dissection may be carried proximally.

Applying methylene blue or brilliant green to the urethra can help identify the plane between urothelium and squamous epithelium. We routinely inject surrounding tissues with 0.25% lidocaine and 1:200,00 U per mL epinephrine to improve hemostasis. This may assist the dissection. Shallow incisions are made laterally along the dorsal aspect of the urethra to begin the dissection (Fig. 99.7). Sharp dissection is required to develop the plane between the urethral wedge and the corporal bodies. Careful dissection will preserve urethral width and length. This is particularly important because the urethra is often too short to reach the glans penis once the bladder has been moved into the pelvis.

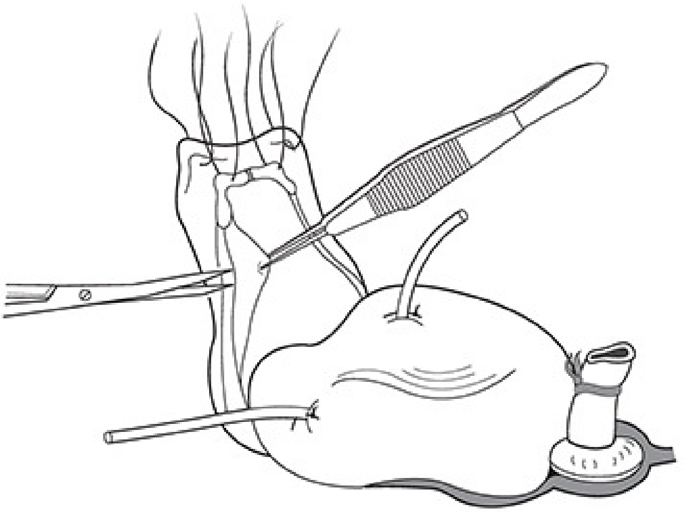

FIGURE 99.7 The urethra is dissected from the corporal bodies. This plane of dissection is developed from both a ventral and lateral perspective using sharp dissection.

Careful lateral dissection of the penile shaft skin and dartos fascia from the corporal bodies will avoid damaging the laterally located neurovascular bundles on the corpora of the epispadic penis. The lateral dissection on the penis should be superficial to the Buck fascia because of the lateral location of the neurovascular bundles in the epispadic penis.

Complete Penile Disassembly and Deep Dissection

Once a plane is established between the penis and the urethral wedge (Fig. 99.8), the penis may be disassembled into three components: (a) the right and (b) left corporal bodies with their respective hemiglans and (c) the urethral wedge (urothelium with underlying corpora spongiosa). This is done primarily to provide exposure to the intersymphyseal band and to allow adequate proximal dissection. We have found that the easiest plane of dissection to completely isolate the corporal bodies is proximal and ventral (Fig. 99.9). The plane of dissection should be carried out at the level of the tunica albuginea on the corpora. After a plane is established between the urethral wedge and the corporal bodies, this dissection is carried distally to separate the three components from each other (Fig. 99.10). Complete separation of the corporal bodies increases exposure to the pelvic diaphragm for deep dissection but is not always necessary as extensive dissection of the corporal bodies while leaving the glans attached often provides acceptable exposure to the pelvic diaphragm. The corporal bodies may be completely separated from each other because they exist on a separate blood supply (see Figs. 99.9 and 99.10). It is important to keep the underlying corpora spongiosa with the urethra; the blood supply to the urethra is based on this corporal tissue, which should appear wedge-shaped after its dissection from the adjacent corpora cavernosa. The urethral/corpora spongiosa component will later be tubularized and placed ventral to the corporal bodies. Paraexstrophy skin flaps are not recommended with this technique because this maneuver will place the blood supply to the distal urethra at risk. Because the bladder and urethra are moved posteriorly in the pelvis as a unit (with a common proximal blood supply), division of the urethral wedge is counterintuitive to the intent of the repair. In many cases, a male patient will be left with a hypospadias that will require later surgical reconstruction.

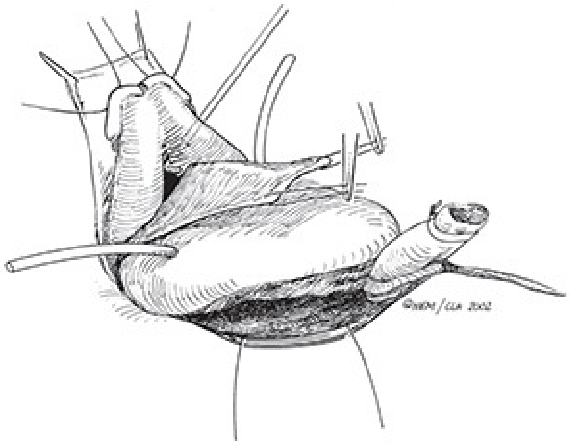

FIGURE 99.8 Disassembly of the corporal bodies from the urethra and corpora spongiosa (the urethral wedge) can often be most easily begun at the position depicted here. The dissection is carried distally to completely separate the glans penis.

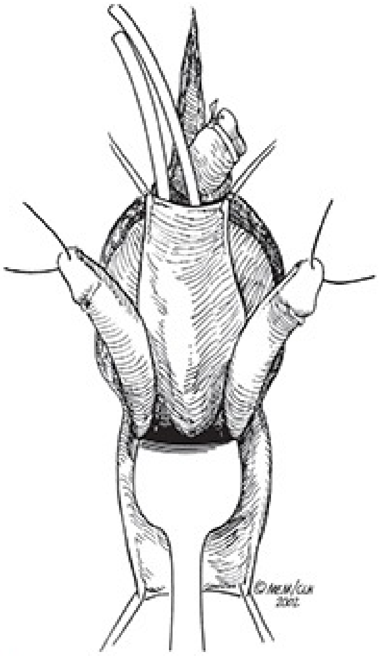

FIGURE 99.9 Perineal view of complete disassembly. Notice depth of dissection.

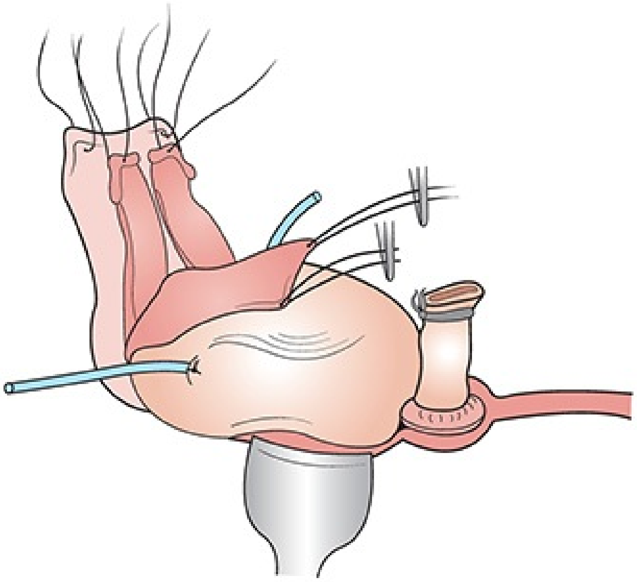

FIGURE 99.10 The urethra and corporal bodies are separated distally to allow deep dissection of the pelvic floor musculature.

Modifications. The urethra and corporal bodies do not always have to be separated; occasionally, the urethra is long enough and the bladder mobile enough to preserve the connection between them while still effectively carrying out the deep pelvic dissection that is integral to this repair. The surgeon should assess the mobility of the bladder and urethra to assess whether separation of the urethra and from the corporal bodies will assist in placing the bladder into the pelvis and whether separation will aid in penile length and straightening.

After separating the components distally, the urethral dissection is carried proximally to the bladder neck. Exposure to the pelvic diaphragm is optimized by complete separation of the urethra and corporal bodies (see Fig. 99.10). This creates the surgical exposure to perform the deep incision of the intersymphyseal band required to move the bladder and urethra posteriorly. When dissecting the urethral wedge from the corporal bodies medially, the dissection plane is on the tunica albuginea of the corpora cavernosa (see Fig. 99.9). This medial dissection should be carried down through the intersymphyseal band (the condensation of anterior pelvic fascia and ligaments) (see Fig. 99.3 inset).

Deep incision of the intersymphyseal band posterior and lateral to each side of the urethral wedge is essential to allow the bladder and bladder neck to achieve a posterior position in the pelvis. This dissection should be carried until the pelvic floor musculature becomes visible. Failure to adequately dissect the bladder and urethral wedge from these surrounding structures will prevent posterior movement of the bladder in the pelvis and create anterior tension along the urethral plate.

Primary Closure

Once the intersymphyseal band is adequately incised and the bladder and urethral wedge are adequately dissected from the surrounding tissues, the bladder and urethra can be reapproximated. This portion of the repair is straightforward and anatomic. To provide urinary drainage, we place a suprapubic tube and bring it out through the umbilicus. We then perform a primary closure of the bladder using a three-layer closure with monofilament absorbable suture (i.e., Monocryl and Vicryl). The urethra is tubularized using a one- or two-layer running closure with monofilament and braided absorbable suture (see Fig. 99.5). Because of the previous deep dissection, we can position the tubularized urethra ventral to the corpora in a tension-free fashion. If the urethra cannot be positioned ventrally without creating tension, it is likely that a deeper incision is required into the intersymphyseal band and pelvic fascia.

We reapproximate the pubic symphysis using two large (0 and no. 1) polydioxanone interrupted sutures placed in a figure-of-eight fashion. Knots are left anteriorly to prevent suture erosion into the bladder neck (Fig. 99.11). The rectus fascia is reapproximated using an interrupted or running 2-0 polydioxanone suture (PDS). We also place interrupted 6-0 PDS along the dorsal aspect of the corporal bodies to reapproximate them (Fig. 99.12). We provide penile skin coverage by using either a primary dorsal closure or reversed Byars flaps if needed. The skin covering the abdominal wall is reapproximated using a two-layer closure of absorbable monofilament suture.

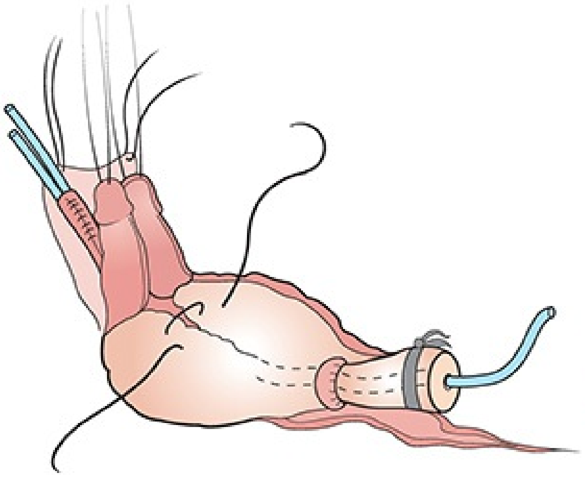

FIGURE 99.11 After the bladder and urethra are reconstructed, these structures will move posteriorly. The urethra will assume a more normal anatomic position. The pubic symphysis is reapproximated with two figure-of-eight sutures.

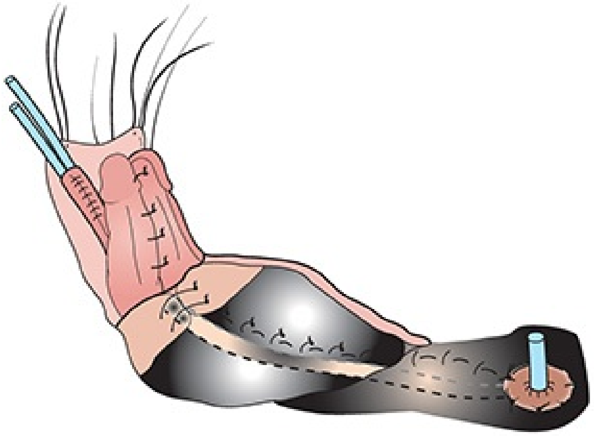

FIGURE 99.12 The corporal bodies will rotate medially so that the neurovascular bodies are located medially. The suprapubic tube can be brought out through the umbilicus. The umbilicus is moved superiorly to a more normal anatomic location.

The corporal bodies will rotate medially with closure (see Fig. 99.11). This rotation will assist in correcting the dorsal deflection and can be readily appreciated by observing the new vertical lie of the previously horizontally placed glans traction sutures. Occasionally, significant discrepancies in the dorsal and ventral lengths of the corpora will require dermal graft insertion to correct chordee.

If there is adequate urethral length, the urethra may be brought up to each hemiglans ventrally to create an orthotopic meatus (see Fig. 99.12). We reconfigure the glans using interrupted mattress PDS followed by horizontal mattress sutures of 7-0 monofilament suture to reapproximate the glans epithelium. The neourethra is matured with 7-0 braided polyglactin suture similar to our standard hypospadias repair. When needed, we also perform glans tissue reduction to create a conical-appearing glans and to eliminate the furrow between the glans halves. Tacking sutures are placed ventrally and dorsally to prevent penile shaft skin from riding over the corporal bodies and “burying” the penis (Figs. 99.4 and 99.13).

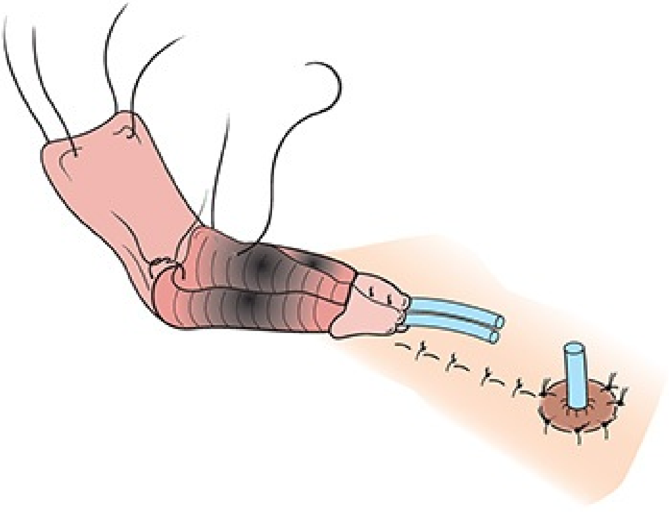

FIGURE 99.13 The ventral shaft skin is secured to the base of the penis to prevent the penile shaft skin from riding over the body of the penis. The ureteral catheters are brought out through the urethra.

In our hands, the urethra lacks enough length to reach the glans in about half the cases. In this situation, we mature the urethra along the ventral aspect of the penis to create a hypospadias. This can be corrected at a later date as a second-stage procedure (6,7). We often leave redundant shaft skin ventrally in these patients to assist in later penile reconstructive procedures.

The Primary Repair Technique: Girls

The principles of this single-stage technique are similar in boys and girls. After preoperative antibiotics are given, the patient is prepared and draped in a sterile field. We mark the planned lines of incision (Fig. 99.14) with the bladder neck, urethra, and vagina mobilized as a unit. We perform this dissection with a tungsten-tip electrocautery (Colorado tip) to minimize tissue damage while achieving hemostasis. The appropriate plane of dissection is found anteriorly along the medial aspect of the glans clitoris and proceeds posteriorly along the lateral aspect of the vaginal vault (Fig. 99.15). The vagina is mobilized with the urethra and bladder neck. Dissection along the vaginal wall extends quite laterally. Placement of a hemostat in the vaginal vault will help with retraction to identify the plane of dissection. The urethra and bladder neck should not be dissected from the anterior vaginal wall, as this will compromise the blood supply to the urethra. During the posterior lateral dissection, the intersymphyseal band will be encountered and should be deeply incised to allow the urethra and bladder neck to move posteriorly. The posterior limit of the dissection is reached when the pelvic floor musculature is exposed and the bladder, bladder neck, and urethra can move into the pelvis without tension.

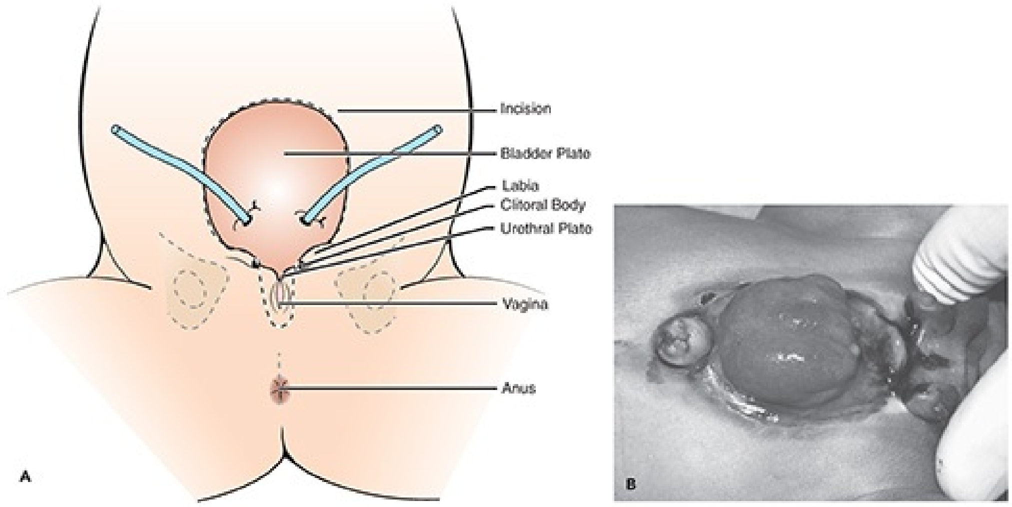

FIGURE 99.14 A: Schematic diagram of lines of incision for complete primary repair of a female infant with bladder exstrophy. This concept has been applied to the repair of female epispadias in the adjacent photograph (B), demonstrating lines of incision for an infant girl with epispadias. Note the posterior extent of dissection to allow movement of the vagina, bladder neck, and urethra as a unit posteriorly.

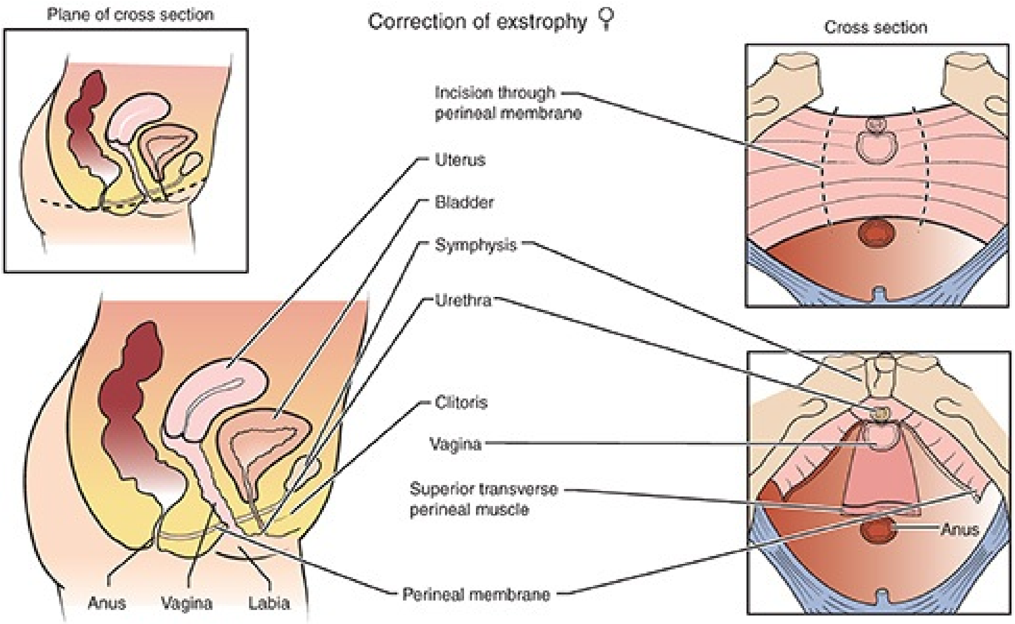

FIGURE 99.15 The plane of dissection lies adjacent to the urethra and vaginal vault (*dashed lines in upper right cross-sectional view*).

Following adequate dissection, the vagina, urethra, and bladder neck are moved posteriorly using a Y-V plasty if the vagina is anteriorly located (Fig. 99.16). The urethra is then tubularized using a two-layer closure of absorbable suture. Prior to the urethral closure, we routinely place a suprapubic tube to provide postoperative urine drainage. The pubic symphysis is reapproximated using two figure-of-eight no. 1 PDS (Fig. 99.17). Osteotomies may be necessary when a wide pubic diastasis prevents a low-tension reapproximation of the pubic symphysis or if the patient is older than 48 to 72 hours old. We use anterior iliac osteotomies in these situations. The rectus fascia can then be closed in the midline. We mature the neourethra with 5-0 Vicryl sutures and reapproximate the bifid clitoris but do make an effort to construct them as one unit (Fig. 99.18). The labia majora should be advanced posteriorly to the perineum at this time as well. A Z-plasty skin closure aids in skin closure. A simplified monsplasty technique described by Pippi-Salle et al. provides a satisfactory aesthetic result to the introital area and can be applied at the time of the primary repair (8).

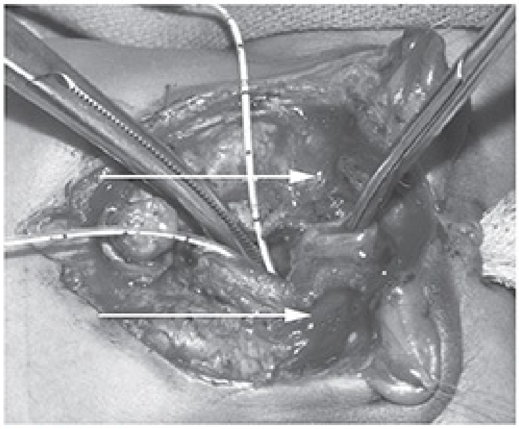

FIGURE 99.16 The intersymphyseal band is incised laterally (*white arrows*) to allow the urethra, bladder, and vaginal vault to move posteriorly as a unit.

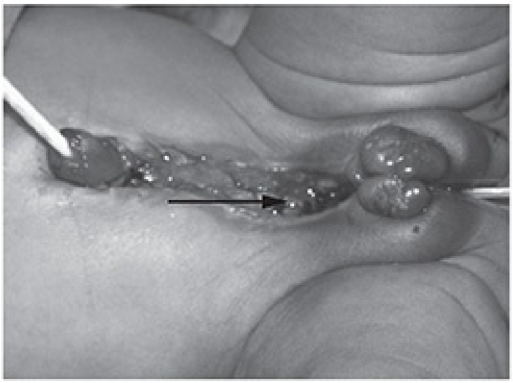

FIGURE 99.17 The pubic symphysis is reapproximated (*arrow*). With adequate dissection, the pubic symphysis can be reapproximated with minimal compressive effects on the urethra and bladder.

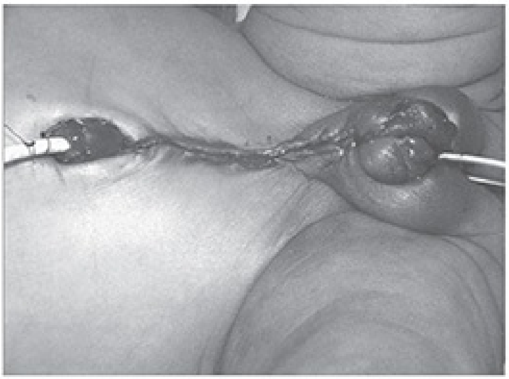

FIGURE 99.18 Final reconstruction demonstrates apposition of the labia and clitoral bodies. Denuding the epithelium on the clitoris medially improves the cosmetic results postoperatively but is not necessary and may damage the clitoris.

Adjunctive Aspect of Repair

Inguinal hernias are commonly associated with exstrophy in both male and female patients. The majority of these hernias occur indirectly. They arise as a consequence of enlarged internal and external inguinal rings combined with compromised fascial support and lack of obliquity of the inguinal canal. In a review of patients from the Toronto Sick Children's Hospital, 56% of classic male exstrophy patients and 15% of classic female exstrophy patients developed inguinal hernias over a 10-year period (9). The authors recommended that these hernias be repaired at the time of primary bladder closure to prevent incarcerated hernias, which could affect up to 50% of these patients in the first 2 years of life. Reinforcement of the transversalis and internal oblique fascia during hernia repair decreases the incidence of later direct inguinal hernias. Umbilical hernias, as a contiguous defect with the bladder plate, also uniformly occur with exstrophy and are repaired at the time of the primary repair.

POSTOPERATIVE CARE

The patient must be immobilized to decrease lateral stresses on the closure after the primary reconstructive procedure for exstrophy. A number of options exist for this purpose. We currently prefer to use a spica cast for 3 to 6 weeks to prevent external hip rotation and to optimize pubic apposition, which can facilitate early discharge and home care (Fig. 99.19). Modified Buck traction has been used by many groups with success or splinting techniques can be used as well (10). A posterior lightweight splint can be used in newborns when the child is out of traction to maintain hip adduction. We have stopped using Buck traction because spica casts are easier for the families to care for at home. External fixation devices have also been used with success (10). Fixator pins for these devices should be cleaned several times a day to reduce the chance for infection. Internal fixation may be necessary in older patients.

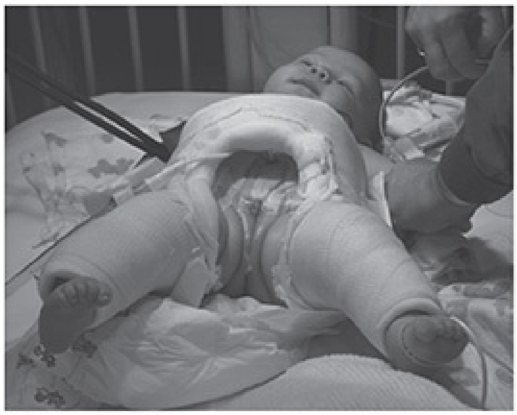

FIGURE 99.19 Use of a spica cast postoperatively to immobilize the pelvis and prevent hip abduction.

Because of the high incidence of vesicoureteral reflux, we prescribe low-dose suppressive antibiotic therapy for all newborns after bladder closure. This is continued until the vesicoureteral reflux is corrected or resolves spontaneously. Some surgeons perform neoureterocystotomies at the time of initial closure. The success of this approach has not been reported.

Postoperative factors that appear to directly impact the success of initial closure include postoperative immobilization, use of postoperative antibiotics, ureteral stenting catheters, adequate postoperative pain management, avoidance of abdominal distention, adequate nutritional support, and secure fixation of urinary drainage catheters.

OUTCOMES

Complications

Complications can occur with this form of exstrophy closure. The most commonly reported complication is urethrocutaneous fistula formation (at the penopubic angle dorsally) in males. These fistulas will often close spontaneously. They may initially be managed conservatively by providing urinary diversion via catheter drainage. If the fistula does not close after conservative management, the bladder and urethra should be examined cystoscopically for the possibility of obstruction at the bladder neck or urethra.

Other complications have been reported following a primary reconstructive technique. These include atrophy of the corpora cavernosa and urethra. These complications can occur if the blood supply to the corporal bodies or urethral wedge is damaged during dissection or during closure (11). Similar complications have been described following the initial stage of a staged reconstruction (12,13). In experienced hands, such complications are unusual and underscore the importance of involving surgeons experienced in the surgical management of these patients in their care.

If a child develops chronic bladder and kidney infections following exstrophy closure, he or she should be evaluated for possible outlet obstruction. We routinely maintain our patients on suppressive antibiotic therapy because of the high incidence of vesicoureteral reflux in this population.

Results

The longest series reporting outcomes of complete primary repair of exstrophy (CPRE) is from Seattle Children's Hospital, spanning 20 years. Median follow-up for 39 patients was reported as 58 months. When the authors assessed children older than 4 years of age, 74% reported daytime continence with volitional voiding and 20% of boys and 43% of girls achieving continence without bladder neck reconstruction or tailoring. Bladder neck procedures prior to achieving continence were performed for other children in the series. The majority of these bladder neck modifications were performed at the same time as ureteral reimplantation procedures and were performed using a Mitchell bladder neck technique. An 18% complication rate was reported in this series (7). In another series using CPRE, Borer and colleagues noted that five of eight patients (63%) 4 years old or older had grossly inadequate bladder outlet resistance and either had or will require bladder neck reconstruction (14). This same group also reported on urodynamic findings between patients who had undergone exstrophy repair using a complete primary repair technique compared to a modern stage repair technique. Patients undergoing a complete primary repair universally had bladder stability and bladder compliance versus those who had been repaired using a staged approach. Bladder capacity was equivalent between the two groups. Interestingly, patients repaired with a complete repair technique also had normal electromyelography results during this study (14–16).

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CHAPTER 100 EXSTROPHY AND EPISPADIAS—MODERN STAGED APPROACH

EZEKIEL E. YOUNG, JOHN P. GEARHART, AND BRIAN M. INOYUYE

Bladder exstrophy is a rare, severe congenital defect that affects the lower urinary tract, genitalia, abdominal wall, and pelvis. The reported incidence ranges from 1:10,000 to 1:50,000 live births, with boys being affected 5 to 6 times more frequently than girls (1). Bladder exstrophy is usually an isolated defect, and in its classic form, associated chromosomal abnormalities or defects of the central nervous system, heart, and digestive tract are extremely uncommon.

Until the middle of the 19th century, bladder exstrophy was treated primarily nonsurgically. Early forms of repair focused on abdominal wall closure using skin flaps for partial reconstruction, leaving a fistula to attach a urinal for dryness. Trendelenburg recognized that pubic reapproximation would not only prevent prolapse of the reconstructed bladder but also be crucial to achieve continence. Although his theoretical assumptions were correct, his surgical efforts were not successful (2). Early failures led to an abandonment of interest in primary closure with a shift toward urinary diversion. In 1942, Hugh Hampton Young performed the first successful primary closure of a female exstrophy patient (3). Although similar reports about continent, primary closures were published in the same era, the numbers were small and most surgeons were not able to reproduce these favorable results. Both Jeffs (4) and Cendron (5) published their descriptions of successful staged anatomic reconstruction in the mid-1970s, and their pioneering work set the standard for the modern staged repair of exstrophy (MSRE). Grady and Mitchell (6) subsequently developed the complete primary repair of exstrophy (CPRE), in which the primary closure is combined with epispadias repair by complete penile disassembly, often resulting in a hypospadias position of the urethral meatus (7).

While older techniques have evolved and alternative approaches have been developed, the primary objectives of modern exstrophy management remain consistent:

1. Secure closure of the abdominal wall, pelvis, bladder, and urethra.
2. Reconstruction of a functional and cosmetically acceptable penis in the male and external genitalia in the female.
3. Urinary continence, preferably via urethral voiding, with preservation of renal function.

The complex embryology and genetics of exstrophy are not well understood. A number of theories have been proposed, which include premature rupture of the cloacal membrane, arrested mesenchymal ingrowth, and failure of cranial yolk sac progression during development (1). In its classic form, bladder exstrophy describes the condition in which an exteriorized bladder template develops in association with a diastasis of the pubic symphysis. This pubic separation results in characteristic genital and pelvic abnormalities. The pubic diastasis is found in association with foreshortened, externally rotated anterior pubic rami and a wide pelvic inlet. The perineum is short and broad and there is anterior displacement of the anus. The appearance of the genitalia varies by gender. In boys, the urethra lies in an epispadiac position, splayed open on the dorsal surface of the corporal bodies. The pubic diastasis results in corporal shortening and severe dorsal chordee. The testes are usually descended, but inguinal hernias are extremely common, especially in boys. In girls, the pubic diastasis results in an absence of a mons pubis, with a bifid clitoris and lateral displacement of the labia. Girls usually present with a bifid clitoris and a shortened vagina, often with a stenotic orifice. In isolated epispadias, which can be viewed as the least severe form of exstrophy, the bladder is closed and covered by a normal abdominal wall, but the pubic separation and genital abnormalities persist. Degrees of epispadias vary in a manner analogous to hypospadias from the very proximal "complete" epispadias in which the urethra is open through the bladder neck, to minor distal variants. A number of other exstrophy variants have been described (8).

DIAGNOSIS

The definitive diagnosis of bladder exstrophy is made upon recognition of the characteristic physical examination findings at the time of birth. Diagnosis by prenatal ultrasound is becoming more common with advances in sonographic techniques. Ultrasound findings include an absence of bladder filling, an anterior abdominal mass, a low-set umbilicus, abnormal widening of the iliac crests, and an anteriorly displaced scrotum with a small phallus in male fetuses (9). The differential diagnoses include cloacal exstrophy, omphalocele, and gastroschisis. Children with a prenatal diagnosis of exstrophy should be delivered at term via cesarean section. The principal implication of prenatal diagnosis of exstrophy is that most parents will seek early counseling regarding the nature of the disease and will temporarily relocate, if necessary, to a center with experience in exstrophy management. Some parents ultimately decide to terminate their pregnancies. The regionalization of complex surgical care such as that required for exstrophy patients is the subject of current debate and outcomes research.

INDICATIONS FOR SURGERY

Historically, some children with bladder exstrophy have survived without surgical reconstruction. As mentioned previously, the earliest attempts at treatment focused on providing a suitable drainage apparatus that would help to manage chronic wetness and odor. The importance of treating this condition, however, can be inferred from several studies that have investigated the profound negative impact of urinary incontinence and sexual dysfunction on quality of life and social and psychological well-being (10,11). Furthermore, it is known that chronic exposure of the exposed bladder mucosa to the environment results in painful ulceration and metaplastic and ultimately neoplastic changes (12). It seems reasonable to conclude that all children with exstrophy should receive appropriate surgical reconstruction, regardless of their economic circumstances.

ALTERNATIVE THERAPY

Urinary Diversion

Historically, a number of different urinary diversion techniques have been successfully used in the management of exstrophy (13). Although incontinent conduits are rarely indicated in contemporary pediatric practice, reconstructive urologists should be comfortable employing them in very select circumstances. Ureterosigmoidostomy was the first successful continent diversion performed for exstrophy, and such patients have demonstrated very good rates of continence without the need for intermittent catheterization (14). The role of ureterosigmoidostomy has decreased with the application of anatomic reconstructions, but it is still used in some centers today. The Mainz II pouch is a modification of the ureterosigmoidostomy that reconfigures the sigmoid into a theoretically lower pressure reservoir, thereby promoting continence and renal preservation (13). Long-term concerns for malignancy at the ureterocolonic anastomosis and renal deterioration necessitate ongoing postoperative surveillance. Urinary diversion remains an important salvage approach in children who fail anatomic reconstruction.

Anatomic Reconstruction

MSRE will be described in detail as performed at Johns Hopkins. Alternate anatomic reconstructions have been proposed and are used in some centers. As is fully described in a separate chapter, Grady and Mitchell (6) developed the one-stage closure in the newborn period, combining primary closure of the bladder, urethra, abdomen, and pelvis with epispadias repair by penile disassembly. Proponents of CPRE believe that this approach will promote bladder growth and better continence outcomes by initiation of bladder cycling early on (6). Schrott (15) describes bladder closure, ureteral reimplantation, epispadias repair, and bladder neck reconstruction in the newborn period, applying the same technique to even older children without osteotomies. Primary newborn exstrophy closure followed by subsequent combined bladder neck reconstruction and epispadias repair has been described by Baka-Jakubiak (16). The combination of bladder closure with modified Cantwell–Ransley epispadias repair has been reported in a series of delayed and secondary exstrophy closures (17).

SURGICAL TECHNIQUE

Preoperative Considerations

A type and screen with baseline complete blood count and coagulation studies should be obtained. A plain film of the pelvis allows for precise measurement of the pubic diastasis. A baseline renal/bladder ultrasound is recommended to establish the presence of both units and for purposes of later comparison. Three-dimensional magnetic resonance imaging is obtained in all of our patients preoperatively but remains investigational. The umbilical cord should be ligated with a heavy silk suture. If a plastic cord clamp was used initially, this should be changed in order to prevent it from irritating the bladder mucosa. Likewise, the bladder template should be kept moist with periodic saline irrigation and covered with either a hydrated gel or Saran-type dressing. Petroleum-based gauze dressings are discouraged as they may dry and denude the mucosa when removed. Latex precautions are recommended, as many of these children will develop latex sensitivity or allergy later in life.

Timing and Staging

Modern staged closure has defined strict criteria for the selection of patients suitable for this approach. The technique includes early bladder, posterior urethral, and abdominal wall closure, usually with pelvic osteotomy in the newborn period, subsequently followed by an early epispadias repair at 6 months of age after intramuscular testosterone stimulation. Around age 4 to 5 years, a competent bladder neck is reconstructed along with bilateral ureteral reimplantation, when adequate bladder capacity is reached and the child demonstrates the maturity necessary to participate in a postoperative voiding program (18).

Successful initial bladder and posterior urethral closure is the most important factor for achieving eventual urinary continence and sufficient bladder capacity. The primary objective in initial, functional closure is to convert the bladder exstrophy into an incontinent penile shaft epispadias, balancing posterior outlet resistance in order to preserve renal function while stimulating bladder growth. The size and the functional capacity of the detrusor muscle are ultimately the most important determinants of success (19). In the presence of a small, fibrotic bladder template without elasticity or contractility, the operation should be deferred until adequate template growth has taken place. If sufficient size is not reached 4 to 6 months after birth, alternative options should be considered. Inguinal hernia repairs should be considered early if the closure is delayed in order to guard against incarceration during this time interval.

The role of pelvic osteotomy performed at time of initial closure ensures a tension-free approximation of the bladder, posterior urethra, and abdominal wall, and placement of the urethra deep within the pelvic ring, enhancing bladder outlet resistance, and aligning the large pelvic floor muscles to support the bladder neck. Usually, osteotomies are not needed in the patient <72 hours old with malleable pubic bones that are easily brought together in the midline by medial rotation of the greater trochanters. However, if the pubic bones are >4 cm apart or unable to be reapproximated without tension under anesthesia, osteotomies are mandated to ensure a secure closure.

Osteotomy

The bilateral anterior innominate and vertical iliac osteotomy has been used in our institution because it has numerous advantages over the posterior approach. The patient is placed in a supine position, preparing and draping the lower body below the costal margins and placing soft absorbent gauze over the exposed bladder. The pelvis is exposed from the inferior wings inferiorly and the pectineal tubercle posteriorly to the sacroiliac joints. The periosteum and sciatic notch are carefully elevated and a Gigli saw is used to create a transverse innominate osteotomy exiting anteriorly at a point halfway between the anterosuperior and the anteroinferior spines (Fig. 100.1). This osteotomy is created at a slightly more cranial level than that described for a Salter osteotomy to allow placement of external fixator pins in the distal segments. Also, the posterior ileum may be incised from the anterior approach in an effort to correct the deformity more completely. This is important because anatomic studies have shown that the posterior portion of the pelvis is also externally rotated in patients with exstrophy, and as patients age, they lose the elasticity of their sacroiliac ligaments. An osteotome is used to create a closing wedge osteotomy vertically and just lateral to the sacroiliac joint. The posterior iliac cortex is kept intact and used as a hinge. Two fixator pins are placed in the inferior osteotomized segment and two pins are placed in the wing of the ilium superiorly. Radiographs are obtained to confirm pin placement, soft tissues are closed, and the urologic procedure is performed. At the conclusion of the exstrophy closure, external fixators are applied between the pins to hold the pelvis in a correct position.

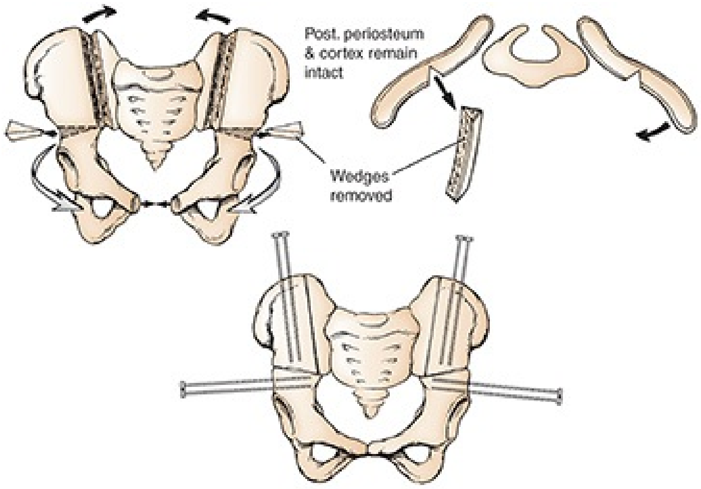

FIGURE 100.1 Combined transverse anterior innominate and anterior vertical iliac osteotomies with pin placement and preservation of the posterior periosteum and cortex. (Drawings by Timothy Phelps after Leon Schlossberg. Copyright © 2013 Brady Urological Institute, with permission.)

Radiographs are taken 7 to 10 days postoperatively. If the diastasis has not been completely reduced, the right and left sides can be gradually approximated using the fixator bars over several days. Light longitudinal Buck skin traction is used to keep the legs still. The patient remains supine in traction for approximately 4 weeks to prevent dislodgement of tubes and destabilization of the pelvis. The external fixator is kept on for approximately 6 weeks, until adequate callus is seen at the site of osteotomy. The pins are removed under light sedation at the bedside. Postoperatively, newborns undergoing closure without osteotomy are immobilized in modified Bryant traction for 4 weeks with the hips in 90 degrees of flexion.

Staged pelvic closure in the setting of an extreme (>8 cm) pubic diastasis has been described with good results in a series of children with both classic and cloacal exstrophy. In this approach, osteotomies are performed in conjunction with interfragmentary pin placement during the initial procedure. The pelvis is then gradually reduced under sedation at the bedside over the next several weeks, and ultimately, the pubis is secured with an interpubic stainless steel plate that is placed at the time of bladder and urethral closure (20).

The use of spica casting and mummy wrapping for immobilization following exstrophy closure has been described. In our experience, these techniques are associated with higher rates of complications and inferior surgical outcomes and are not recommended (21). Okubadejo et al. (22) reviewed the orthopedic complications of exstrophy management in 624 patients from Johns Hopkins: 26 complications were noted (4%), of which four were identified as being specifically caused by traction.

Bladder, Posterior Urethral, and Abdominal Wall Closure

The various steps in primary bladder closure are illustrated in Figure 100.2. A 2-cm wide strip of mucosa is outlined for prostatic and urethral reconstruction, extending from the distal trigone well onto the penile shaft in boys, and to the vaginal orifice in females (Fig. 100.2A). With the advent of the modified Cantwell–Ransley epispadias repair, the urethral plate should not be incised unless the length of the urethral groove, from the verumontanum to the glans, is so short that it produces dorsal angulation and will likely interfere with eventual penile length. In this situation, the urethral groove is lengthened. Figures 100.2B to 100.2D show marking of the incision from just above the umbilicus down around the junction of the bladder and the para-exstrophy skin to the level of the urethral plate. The appropriate plane is entered just above the umbilicus and a plane is established between the rectus fascia and the bladder (Fig. 100.2E and F). The umbilical vessels are doubly ligated and incised and allowed to fall into the pelvis. The peritoneum is taken off the dome of the bladder to be deeply placed into the pelvis at the time of closure. The plane is continued caudally down between the bladder and rectus fascia until the urogenital diaphragm fibers are encountered bilaterally. With electrocautery, these urogenital diaphragm fibers between the bladder neck, the posterior urethra, and the pubic bone are sharply taken down in their entirety to the levator hiatus (see Fig. 100.2F). A double-pronged skin hook can be inserted into the pelvic bone and pulled laterally to accentuate the urogenital diaphragm fibers. If this maneuver is not performed adequately, the vesicourethral unit will be brought anteriorly with pelvic closure in an unsatisfactory position for later reconstruction.

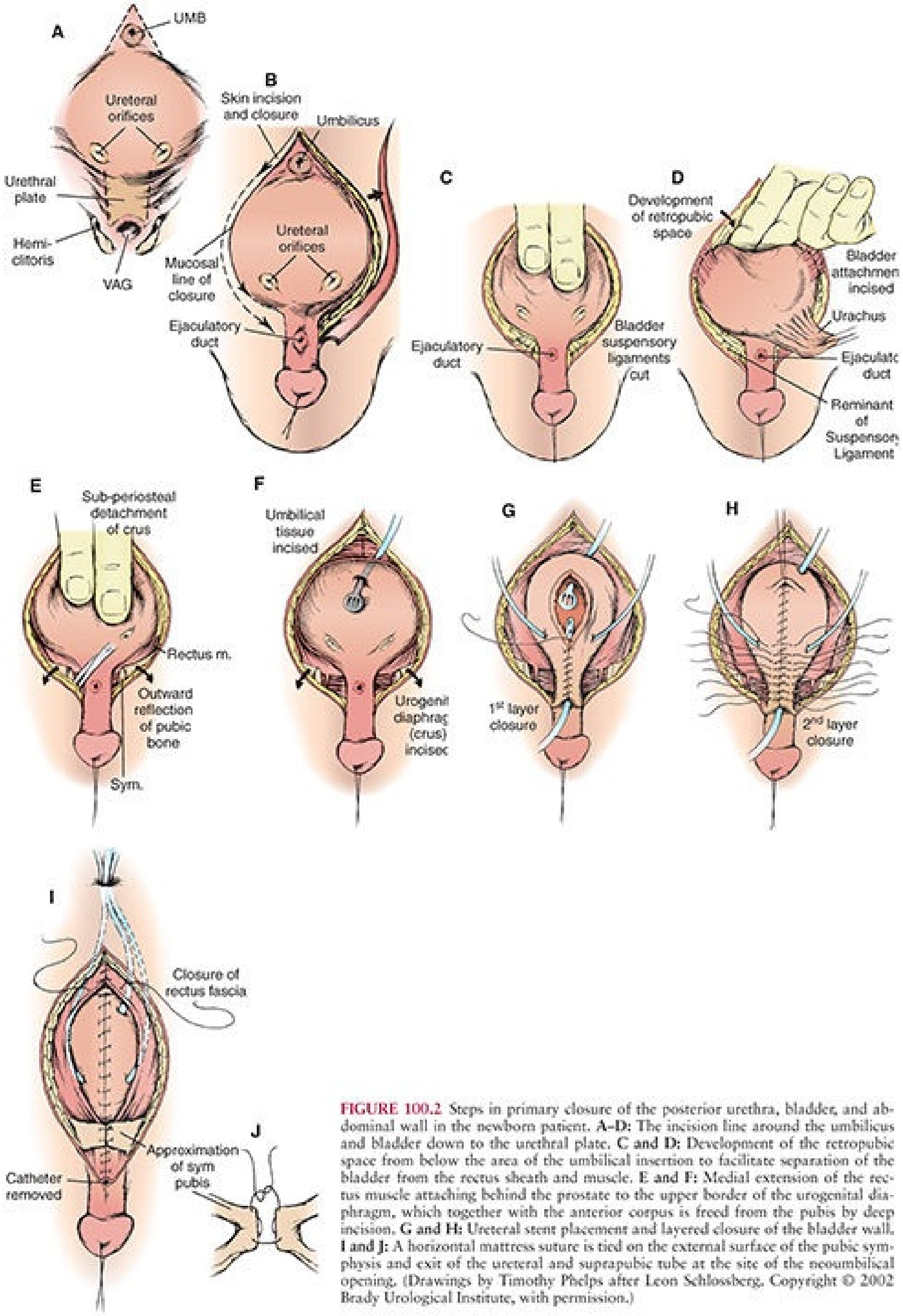

FIGURE 100.2 Steps in primary closure of the posterior urethra, bladder, and abdominal wall in the newborn patient. **A–D:** The incision line around the umbilicus and bladder down to the urethral plate. **C and D:** Development of the retropubic space from below the area of the umbilical insertion to facilitate separation of the bladder from the rectus sheath and muscle. **E and F:** Medial extension of the rectus muscle attaching behind the prostate to the upper border of the urogenital diaphragm, which together with the anterior corpus is freed from the pubis by deep incision. **G and H:** Ureteral stent placement and layered closure of the bladder wall. **I and J:** A horizontal mattress suture is tied on the external surface of the pubic symphysis and exit of the ureteral and suprapubic tube at the site of the neoumbilical opening. (Drawings by Timothy Phelps after Leon Schlossberg. Copyright © 2002 Brady Urological Institute, with permission.)

If the decision is made to transect the urethral groove, then it is cut distal to the verumontanum with continuity maintained between the thin, mucosa-like non–hair-bearing skin adjacent to the posterior urethra and bladder neck and the skin and mucosa of the penile glans. Thin skin flaps are then developed and rotated distally to reconstruct the urethral groove, resurfacing the penis dorsally. The corporal bodies are not brought together because later Cantwell–Ransley epispadias repair requires the urethral plate to be brought underneath the corporal bodies. If the urethral plate is left in continuity, it must be mobilized up to the level of the prostate to create as much urethral and penile length as possible. Apparent penile lengthening is achieved by exposing the corpora cavernosa bilaterally and freeing the corpora from their attachments to the suspensory ligaments. After the urogenital diaphragm is completely incised bilaterally, freeing the bladder neck and urethra well from the pubis, the mucosa and muscle of the bladder and posterior urethra are closed in the anterior midline down onto the midshaft penis (Fig. 100.2G). The resulting orifice should be easily passed by a 12Fr sound, creating enough resistance to aid in bladder adaptation and prevent prolapse but not so much as to cause undue outlet resistance altering the upper tracts. A second layer is closed if possible (Fig. 100.2H). Bladder drainage is achieved using a suprapubic nonlatex Malecot catheter for 4 weeks.

The urethra is left unstented to prevent necrosis. Ureteral stents are left in place for 10 to 14 days, until swelling goes down.

By applying gentle pressure over the greater trochanters bilaterally, the pubic bones are approximated in the midline. A horizontal mattress suture of no. 2 nylon is placed between the fibrous cartilages of the pubic rami and tied anteriorly to the pubic closure to avoid the neourethra (Fig. 100.2I and J). A second stitch is placed caudal to the insertion of the rectus fascia if possible for added support. Should the sutures work loose or cut through the tissues during subsequent healing, the anterior placement of the knot of the horizontal mattress suture ensures that it will not erode through into the urethra. At a point corresponding to the normal position of the umbilicus, a V-shaped flap of abdominal skin is tacked down to the abdominal fascia, and the drainage tubes exit this neoumbilicus.

Postoperatively, before removing the suprapubic tube, the bladder outlet is calibrated to ensure free passage of urine. Repeated ultrasound examinations are obtained before discharge and every 3 months thereafter to monitor for upper tract dilatation and residual urine. Continuous, prophylactic antibiotic therapy is advised to prevent upper tract infection from ureteral reflux. Yearly gravity cystograms under anesthesia are performed to receive quality information about reflux and, more importantly, bladder capacity. Successful continence procedures necessitate a minimal bladder capacity of 100 mL (19). An increase in bladder capacity is typically seen after epispadias repair, which is why the bladder neck procedure is performed after the urethral reconstruction.

Epispadias Repair

Four key concerns have to be addressed: (a) a functional and cosmetically pleasing penis, (b) correction of dorsal chordee, (c) urethral reconstruction, and (d) penile skin closure and glandular reconstruction. In patients undergoing delayed repair or reclosure, a combined epispadias/exstrophy closure using the modified Cantwell–Ransley repair is possible.

The modified Cantwell–Ransley repair is begun by placing a nylon suture through the ventral glans for traction. A meatal advancement and glanuloplasty incorporated (MAGPI) incision is made in the urethral plate distally and closed with 6-0 polyglycolic sutures in a transverse fashion to flatten the distal urethral plate and advance the urethra to the tip of the phallus (Fig. 100.3A). The reconstructed neourethra will be in excellent glandular position once the wings are closed. Next, two parallel pre-marked incisions are made along the dorsum of the penis, outlining an 18 mm wide strip of urethral mucosa extending from the prostatic urethral meatus to the tip of the glans (see Fig. 100.3A). Triangular mucosal areas of the dorsal glans are excised adjacent to the urethral strip, and thick glanular flaps are constructed bilaterally. Lateral skin flaps are mobilized and undermined.

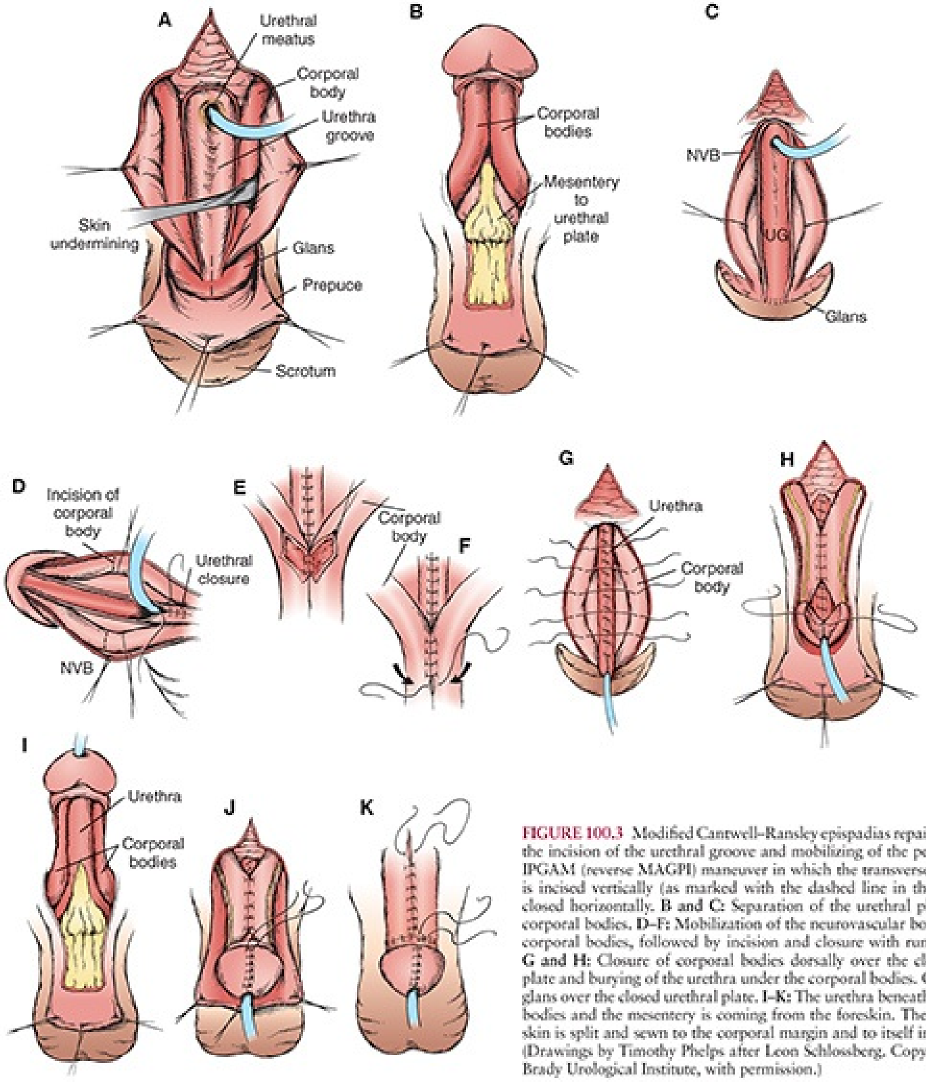

FIGURE 100.3 Modified Cantwell–Ransley epispadias repair. **A:** Marking the incision of the urethral groove and mobilizing of the penile skin and IPGAM (reverse MAGPI) maneuver in which the transverse urethral bar is incised vertically (as marked with the dashed line in the glans) then closed horizontally. **B and C:** Separation of the urethral plate from the corporal bodies. **D–F:** Mobilization of the neurovascular bodies from the corporal bodies, followed by incision and closure with running sutures. **G and H:** Closure of corporal bodies dorsally over the closed urethral plate and burying of the urethra under the corporal bodies. Closure of the glans over the closed urethral plate. **I–K:** The urethra beneath the corporal bodies and the mesentery is coming from the foreskin. The ventral foreskin is split and sewn to the corporal margin and to itself in the midline. (Drawings by Timothy Phelps after Leon Schlossberg. Copyright © 2002 Brady Urological Institute, with permission.)

A Z-incision of the suprapubic area permits exposure and division of the suspensory ligament and old scar tissue from the initial exstrophy closure. The ventral skin is taken down to the level of the scrotum (Fig. 100.3B). Care is taken to preserve the mesentery to the urethral plate, which arises proximally and extends upward between the corpora as a blood supply to the urethral plate. The corpora are dissected ventrally on the surface of the Buck fascia. The plane is followed closely bilaterally until one exits on the dorsum of the penis between the corpora spongiosum and the corporal body (Fig. 100.3C).

After placement of loops, the urethral plate is dissected just on the corporal bodies to the level of the prostate and the glans, respectively (Fig. 100.3D). Care is taken to leave the most distal 1-cm attachment of the mucosal plate to the glans intact. The neurovascular bundles are dissected free from the corporal bodies only if rotating the corpora over the urethra does not straighten the penis. The urethral strip is closed in a linear manner from the prostatic opening to the glans over an 8Fr silicone stent with 6-0 polyglycolic sutures. Afterward, the corporal bodies are incised at the point of maximal curvature, leaving a diamond-shaped defect (Fig. 100.3E). The corpora are then closed over the neourethra with two running sutures of 5-0 polydioxanone suture (PDS), with the adjacent areas of the diamond sutured to each other (Fig. 100.3F). The now ventrally placed urethra is secured in place with further 5-0 polyglycolic acid sutures between the corpora, especially at the coronal level (Fig. 100.3G–I). The glans wings are closed in a subcuticular manner with 5-0 and the glans epithelium with 6-0 polyglycolic acid. Finally, the ventral skin is brought up and sutured to the ventral edge of the corona, while the flaps provide coverage of the dorsum. The skin as well as the Z-plasty at the base of the penis is reapproximated with interrupted 5-0 or 6-0 polyglycolic acid sutures (Fig. 100.3J and K). The silicon stent is secured and left for 10 to 12 days.

In girls, the mons and external genitalia are reconstructed at the time of initial exstrophy closure. The bifid clitoris is denuded medially and brought together at the midline, along with labia minora reconstruction, creating a fourchette.

Postoperatively, it is critical to control pain and bladder spasms to prevent urine extravasation and fistula formation. This is best achieved by preoperative placement of a caudal epidural catheter and the administration of anticholinergic medication. At the time of discharge, the postoperative plastic occlusive dressing is left intact and the patient is supplied with oral broad-spectrum antibiotics, pain medications, and antispasmodics.

Continence and Antireflux Procedure

When the child is sufficiently mature and motivated to be dry and has finished an extensive voiding improvement program, bladder neck reconstruction is considered if the bladder capacity is greater than 100 mL and urodynamics demonstrate bladder stability.

The bladder is opened through a vertical incision that is extended transversely at the bladder neck (Fig. 100.4A). Figure 100.4 depicts a Cohen transtrigonal ureteral reimplantation or a cephalotrigonal reimplantation for either moving the ureter across the bladder above the trigone or, if the ureters are too low, moving them on the upper aspect of the trigone (Fig. 100.4B). The modified Young–Dees–Leadbetter procedure is begun by selecting a posterior strip of mucosa 15 to 18 mm wide and 30 mm long that extends from the midtrigone to the prostate or posterior urethra (Fig. 100.4C). The bladder muscle lateral to the mucosal strip is denuded of mucosa and sponges, soaked in 1:200,000 epinephrine, and applied to control bleeding for better visualization. Tailoring of the muscle triangles is aided by multiple small incisions on the free edge bilaterally that allow the area of reconstruction to assume a more cephalic position (Fig. 100.4D). A transverse, full-thickness muscular incision is not performed as described in the original Young–Dees–Leadbetter procedure because there is a significant risk of denervation and ischemia to the bladder neck. The edges of the mucosa and underlying muscle are closed with interrupted sutures of 4-0 polyglycolic acid (Fig. 100.4E). The adjacent denuded muscle flaps are overlapped and sutured firmly in place with a 3-0 PDS to provide reinforcement of the bladder neck and urethral reconstruction (Fig. 100.4F and G). Two or three of the overlapping sutures are left long, brought through the rectus fascia, and tied as bladder suspension to elevate the bladder neck (see Fig. 100.4G). An 8Fr urethral stent may be used during construction but is removed afterward. Exposure is essential for the creation of a continent bladder neck. Therefore, if visualization of the posterior urethra is problematic, the intrasymphyseal bar has to be cut and afterward approximated with 0 PDS nylon sutures. In this case, the child should be immobilized postoperatively.

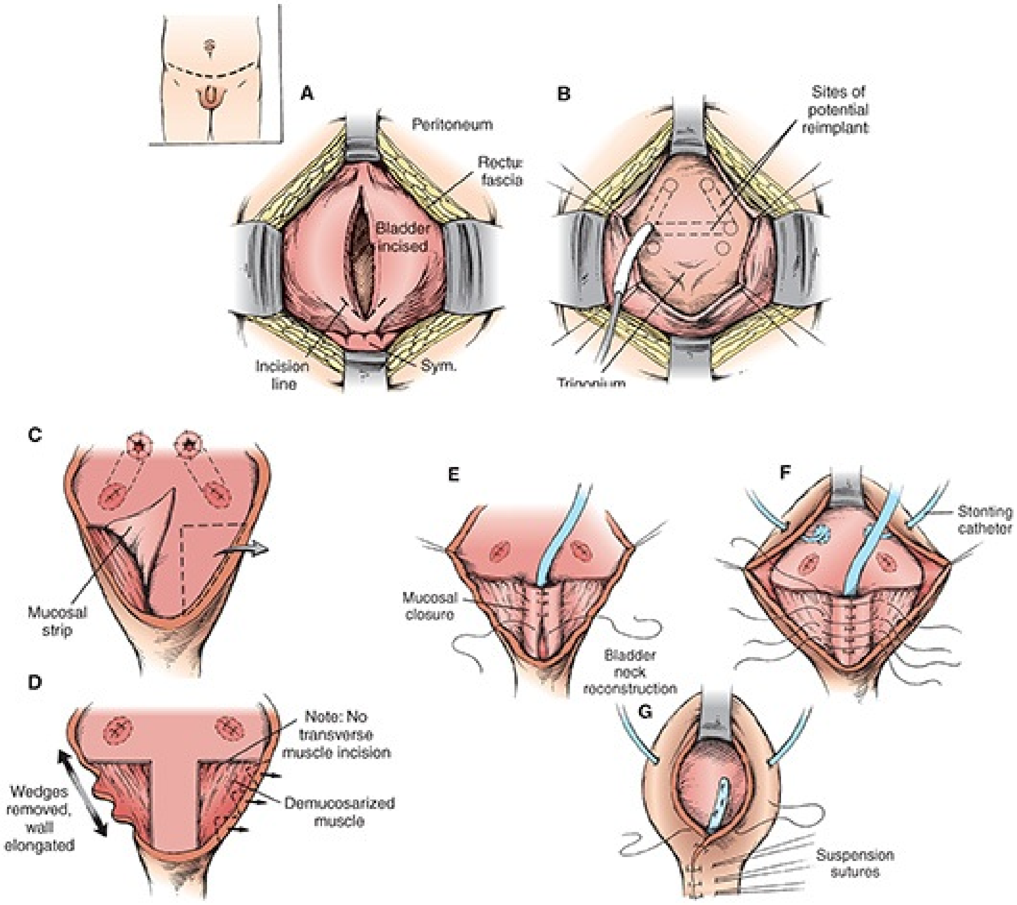

FIGURE 100.4 Modified Young–Dees–Leadbetter bladder neck repair. **A:** Through a Pfannenstiel incision (*inset*), a vertical bladder incision is made with transverse extension distally. **B and C:** Ureteral mobilization for ureteral reimplantation. **C–E:** Use of mucosal trigone strip to form the bladder neck and prostatic urethra. Lengthening of the denuded muscle triangles by several incisions. Note: No transverse muscle incision. **E–G:** Double-breasted closure and exact suture placement of the bladder neck reconstruction. The bladder neck and urethra are unstented at the end of the operation. (Drawings by Timothy Phelps after Leon Schlossberg. Copyright © 2002 Brady Urological Institute, with permission.)

The ureteral stents are left in place until pelvic healing is confirmed by X-ray, typically around 4 weeks. The suprapubic catheter is also usually first clamped around 4 weeks, for no longer than 1 hour on the first occasion. After residual-free voiding is achieved, the suprapubic catheter is removed. The patient is followed up with frequent bladder and renal ultrasounds in the first few months.

OUTCOMES

Complications

Failure of the closure is marked by dehiscence, prolapse, or outlet obstruction. It is possible that these complications are underreported secondary to patients changing surgeons following an initially undesirable outcome. Osteotomy is mandatory at the time of secondary closure in all cases. Outlet obstruction may develop early following removal of the urethral catheter. Surveillance of residual volumes and upper tract dilation with ultrasound is important following removal of the urethral catheter and prior to removing the suprapubic tube. The development of pyelonephritis is likewise a cause for evaluation of the bladder outlet following primary closure. In some cases, calibration and temporary catheter replacement are sufficient. We prefer to calibrate under anesthesia with a cystoscope because this allows for precise catheter placement if needed.

The incidence of urethrocutaneous fistulas following Cantwell–Ransley epispadias repair is 19% at 3 months (23). Some of these will close spontaneously. The majority, however, will require operative repair as an outpatient procedure. Residual chordee is a common indication for revision surgery, usually as an adolescent, prior to becoming sexually active.

It is clear that the bladder needs time to adjust to the increased resistance added by the reconstructed bladder neck. Bladder spasms and detrusor instability are expected and should be treated with oral anticholinergics. The biggest challenge for the child and the parents after bladder neck reconstruction is the initiation of a voiding trial. If the child cannot void, an 8Fr catheter is placed under anesthesia and left in place for 5 days before a second voiding trial. Ultimately, if the child is not dry for a period of 3 hours during the day within 12 months of the operation, the bladder neck reconstruction has failed. Multiple options are available for these children to achieve future continence, but few will void through their urethra.

Results

Long-term functional results are highly related to the success or failure of the initial closure. Bladders that dehisce or prolapse and require repeat closure are not likely to grow and reach the capacity needed for bladder neck reconstruction. In a review of 23 patients with one or more failed closures, we found that only 6 children reached sufficient capacity for bladder neck reconstruction, with a success rate of 50% (24). The use of osteotomy in conjunction with pelvic and lower extremity fixation has produced the best success rates at our institution and is recommended for all closures beyond the first 72 hours of life (i.e., delayed or secondary closures) (20). In a group of 194 primary MSRE closures at Johns Hopkins, 63 of which had simultaneous osteotomy, there were four failures (two dehiscences and two prolapses) (25). Interpretation of continence rates requires consideration for the definition applied and the manner in which the child voids/empties. The ultimate goal remains continence, day and night, with volitional voiding and stable renal function. Daytime dry intervals vary in the literature from 1 to 3 hours. “Social” continence refers to an adequate daytime dry interval with bedtime wetness. The use of catheterizable stomas, with or without bladder augmentation and additional outlet procedures such as artificial urinary sphincters, slings, or bladder neck, should likewise be noted when reviewing published continence rates.

Chan et al. (26) reported complete and social continence rates of 77% and 91%, respectively, with urethral voiding following bladder neck repair in children treated exclusively at Johns Hopkins. Preoperative bladder capacity measured under anesthesia appears to be the primary determinant of success in these patients. Patients with capacities >100 mL are good candidates for modified Young–Dees–Leadbetter procedures (18). Variable continence outcomes of children undergoing CPRE with subsequent Mitchell bladder neck repair have been recently reported (27). Like MSRE, the results of bladder neck repair following CPRE appear to be related to a successful primary closure, and in one report, this was highly associated with the use of osteotomy (17).

There are a number of options for salvage procedures in patients who fail bladder neck repair. Ultimately, however, several series have reinforced the fact that very few of these children will obtain continence with volitional voiding (28,29). Upper tract dilation following exstrophy closure is common, as most of these children have significant degrees of vesicoureteric reflux. It is uncommon for exstrophy patients to develop chronic renal dysfunction following ureteral reimplantation at the time of continence surgery in the MSRE.

It is important to differentiate between functional and cosmetic outcomes of genitoplasty. Cosmetic outcomes rely on subjective patient interpretation. Regarding cosmesis, VanderBrink et al. (30) recently reported a 92% esthetic satisfaction rate in 65 male patients undergoing genitoplasty for exstrophy/epispadias. Nineteen revision procedures were required to obtain this outcome. The majority of these cases were treated with a Cantwell–Ransley technique. From a functional standpoint, prospective studies of sexually active adults are needed to ascertain long-term outcomes. North et al. (31) reported International Index of Erectile Function (IIEF-15) and Female Sexual Function Index (FSFI) scores for a group of adult exstrophy males and females, respectively. When compared to controls, adult males with exstrophy reported similar scores for erection, orgasm, desire, and satisfaction. Females, on the other hand, had poor sexual satisfaction and lower scores when compared to controls in all FSFI domains. The reason for this gender dichotomy is not clear.

CONCLUSION

The modern reconstruction of bladder exstrophy can be quite successful in experienced hands. A successful initial closure can place the child on the road to eventual continence and volitional voiding, while failed closures are likely to result in less satisfactory outcomes that often involve augmentation or continent diversion. If possible, these surgeries should be performed in exstrophy centers in order to provide the greatest chance of improved outcomes and the resultant quality of life.

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CHAPTER 101 PEDIATRIC CRYPTORCHIDISM, HYDROCELES, AND HERNIAS

ANGELA M. ARLEN AND CHRISTOPHER S. COOPER

Between 3% and 5% of full-term male infants are born with an undescended testicle, and a similar percentage will have an inguinal hernia or hydrocele (1). Cryptorchidism is often associated with a patent processus vaginalis, which predisposes to hydrocele and inguinal hernia formation. The treating urologist must therefore be familiar with the anatomy (Fig. 101.1) and operative techniques employed in treating these common pediatric conditions.

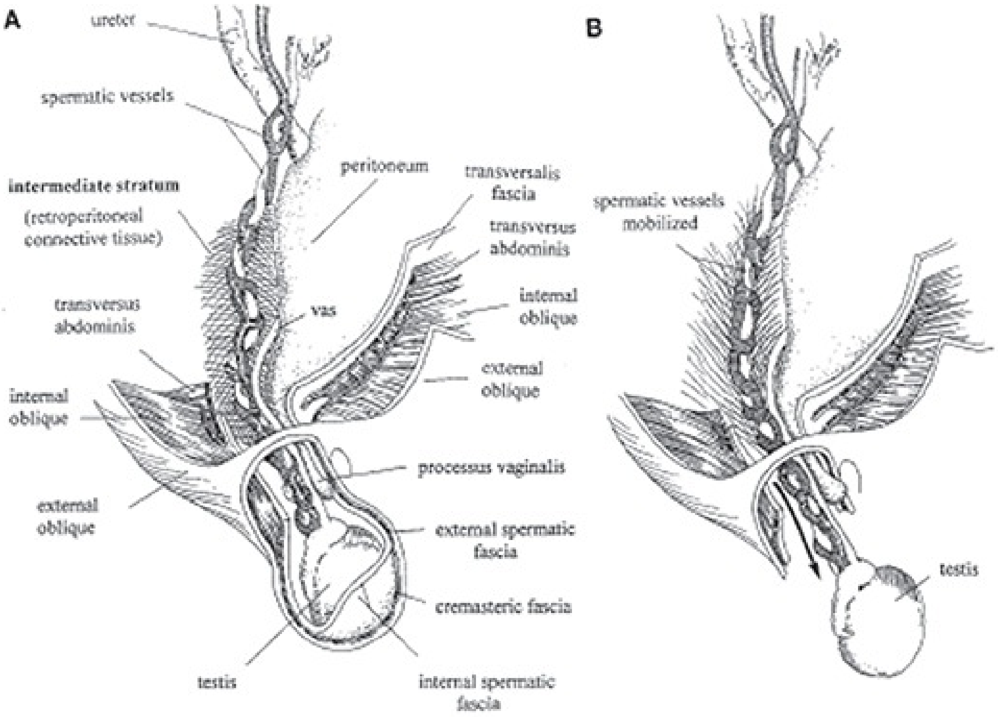

FIGURE 101.1 Anatomy of inguinal orchiopexy. **A:** Relationship of the vas deferens, spermatic vessels, and processus vaginalis to investing fascial layers. The transversalis fascia is contiguous with internal spermatic fascia. **B:** With tension applied to the cord (*arrow*), the orientation of the fibers of the intermediate stratum investing the retroperitoneal spermatic cord is changed so that fibers become parallel to cord structures. Freeing the vas and vessels from this investing fascia is the most important step in achieving distal testicular displacement. (Reprinted with permission from Hutcheson JC, Cooper CS, Snyder HM III. The anatomical approach to inguinal orchiopexy. *J Urol* 2000;164:1702–1704. Copyright © 2000 American Urological Association, Inc. Published by Elsevier Inc. All rights reserved.)

CRYPTORCHIDISM

Cryptorchidism includes the strict definition of an absent or nonpalpable testicle as well as an undescended testis that is palpable in the inguinal canal but fails to reach the scrotum. Twenty percent of boys with cryptorchidism have a nonpalpable testis. Of nonpalpable testes, 20% are intra-abdominal, 40% are canalicular or ectopic, and 40% are atrophic or absent. True undescended testicles stop along their normal path of descent into the scrotum. The testis may be located in the abdominal cavity (least common), inguinal canal, or just caudal to the external ring (suprascrotal, most common). Testes may also pass through the external ring into an ectopic location, most commonly located in a superficial inguinal pouch. Up to 10% of cases are bilateral (2), and the incidence of cryptorchidism increases to 30% in premature infants. Low birth weight has also been associated with cryptorchidism, independent of gestational age (3). The majority of testicles descend within the first 6 months of life, and by 1 year of age, the prevalence is 0.8% to 1%.

Diagnosis

Upon initial evaluation, a thorough history and physical examination is mandatory. Antenatal as well as maternal history for the use of gestational steroids or hormones should be elicited, as well as birth history. Record of physical exam at the time of birth should be obtained if possible. The presence of palpable gonads, hypospadias, and prior inguinal herniorrhaphy should be noted as well as a family history of cryptorchidism and other genitourinary anomalies. The size of the contralateral testis should be documented in cases where compensatory hypertrophy is suspected.

The diagnosis of cryptorchidism relies solely on physical examination. Absence of an identifiable testicle on ultrasound, computerized tomography, or magnetic resonance imaging does not prove testicular agenesis and therefore does not negate the need for surgical exploration (4,5). In children referred to a urologic specialist for undescended testicle, approximately 80% will have a palpable testis on exam. A careful physical examination in a nonthreatening, warm environment is crucial to identifying a subtle but palpable testicle. One hand is placed near the anterior superior iliac spine and the other on the scrotum. The first hand is swept caudally along the inguinal canal to gently draw the testicle toward the scrotum. Placing soap on the fingertips of the palpating hand may improve the sensitivity of palpation. A true undescended or ectopic testis may slide or "pop" under the examiner's fingers during this maneuver. A low ectopic or retractile testicle will be felt by the second hand as the testis is milked toward the scrotum. To distinguish a retractile testis, the testicle is brought into the scrotal position and held in place for several minutes, fatiguing the cremaster muscle. After this maneuver, a retractile testicle remains in the scrotum while an undescended testicle immediately pulls up and out of the scrotum.

A child with bilateral nonpalpable testes should undergo hormonal evaluation for testicular absence (6). Elevations in luteinizing hormone (LH) and follicle-stimulating hormone (FSH) and absence of detectable müllerian inhibiting substance (MIS) suggest lack of testicular tissue (7). Human chorionic gonadotropin (HCG) has a stimulatory effect on testicular steroidogenesis; therefore, testicular absence can be confirmed by a negative HCG stimulation test. HCG stimulation is performed by the administration of 2,000 IU of intramuscular HCG daily for 3 days (8). Elevated gonadotropin levels (LH and FSH) *and* a lack of testosterone rise following HCG indicate bilateral absent testes, and a formal surgical exploration is not necessary. When one or both components are lacking, or there is detectable MIS, surgical intervention is warranted.

Indications for Surgery

Surgical intervention for undescended testicle offers the possibility of improved fertility, correction of associated patent processus vaginalis, prevention of testicular torsion, and improvement in body image. Controversy remains over whether orchiopexy decreases the risk of malignancy, but placement of an undescended testis into the scrotum allows for testicular examination by health care providers as well as the patient (9,10).

At birth, the undescended testicle has been shown to have normal histology; however, delayed germ cell development has been documented in the older infant (11). Histology correlates with testicular position, with worse features associated with higher testes. Because histologic changes related to fertility occur in the undescended testis as early as 1 year of age and spontaneous descent rarely occurs after 6 months, optimal surgical timing is between 6 and 12 months of age. Early surgical intervention has been shown to improve testicular growth (12) and adult Leydig cell function (13). In postpubertal presentation of cryptorchidism, sperm are rarely noted and the testes are at significant risk for malignant change (14,15). Orchiectomy may be considered in this patient cohort if the contralateral testis is located in the scrotum.

Alternative Therapy

Hormonal therapy is an option in the treatment of cryptorchidism because its etiology may be related to an incomplete manifestation of hypogonadotropic hypogonadism. HCG is the only hormone approved for use in cryptorchidism in the United States. Three meta-analyses of randomized controlled studies have been published; all report an overall efficacy of approximately 20%, which on follow-up is decreased to about 15% due to secondary reascent of the testis (16–18). This is compared with up to a 95% success rate of primary orchiopexy, which remains the standard of care for the undescended testis.

Surgical Technique

Prior to surgical intervention, the patient should be re-examined under anesthesia. On occasion, a retractile testis descends under anesthesia or a previously nonpalpable testicle becomes palpable, altering the surgical approach. For a palpable testis, an open inguinal or scrotal approach orchiopexy is performed. Prior to the 1970s, surgical management of the nonpalpable testicle also consisted of inguinal exploration with extension of the dissection into the peritoneum if a testis, nubbin, or blind-ending vessels could not be identified. In 1976, Cortesi et al. (19) described using diagnostic laparoscopy for nonpalpable testis, revolutionizing the diagnosis and surgical management of the intra-abdominal undescended testicle.

Diagnostic Laparoscopy

Indications for diagnostic and therapeutic laparoscopy are identical to the goals of open orchiopexy: Determine if a testicle is present and viable, and if so, relocate it into the scrotum. Historically, laparotomy was performed to localize an intra-abdominal testis or diagnose blind-ending vessels if cord vessels were not observed on initial inguinal exploration. This was most often accomplished with a high inguinal (i.e., Jones incision) or Pfannenstiel incision. It is now common practice, especially as the child grows beyond infancy, to proceed with diagnostic laparoscopy when the testicle is nonpalpable.

During diagnostic laparoscopy for the nonpalpable testis, there are three scenarios that are commonly encountered. If blind-ending vessels and vas deferens are present proximal to the internal ring, a vanishing testis is diagnosed and no further action is required. Approximately 10% of boys with nonpalpable testis are found at the time of diagnostic laparoscopy to have blind-ending vessels, indicating the absence of testicular tissue (20). If the vessels and vas deferens are present and appear to enter the internal ring, then inguinal or scrotal exploration is warranted. The final scenario includes the presence of an intra-abdominal testis, which can be located in a variety of positions. For an intra-abdominal testicle the surgeon will need to assess which therapeutic modality is the most appropriate for treatment. If the testicle appears to be atrophic or grossly abnormal, then orchiectomy should be considered. If the testicle appears relatively normal, the ability to mobilize it to the scrotum is assessed, based on the distance of the testicle to the internal inguinal ring and redundancy of the spermatic vessels and vas. Deciding whether to perform a single-stage procedure leaving the vessels intact or to perform a one- or two-stage Fowler–Stephens procedure in which the spermatic vessels will be transected is challenging as no specific set of criteria have been determined. As part of the decision-making process, intraoperative measurement of the distance between the testis and the internal ring, observation of the cord anatomy, or assessment of the ability of the intra-abdominal testicle to reach the opposite inguinal ring after dissection may be helpful. Bilateral laparoscopic orchiopexies can be performed simultaneously or at separate procedures, depending on perceived risk of atrophy.

Diagnostic Laparoscopy Technique. Inhaled NO_2 should be avoided in order to avoid bowel distention, and an oral gastric tube should be inserted to decompress the stomach and maximize visualization in the abdomen. The patient is secured to the bed in the supine position at the level of the chest and low thigh with his arms tucked and the legs placed in a slightly abducted position. Securing the child to the table allows for Trendelenburg positioning. Prep and drape the patient for possible conversion to an open procedure. In the sterile field, a Foley catheter is placed to avoid potential bladder injury with trocar placement. Figure 101.2 demonstrates the preferred setup and trocar placement for performing laparoscopic orchiopexy.

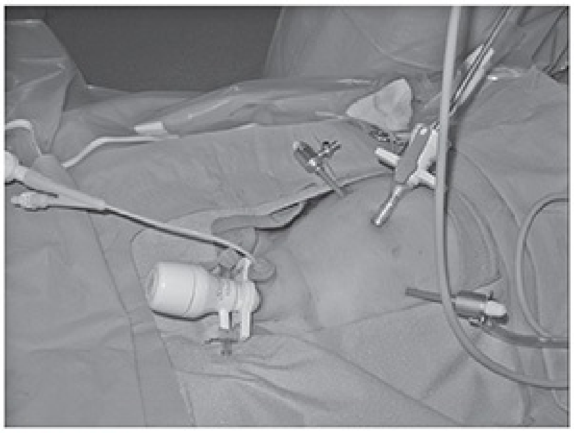

FIGURE 101.2 Preferred setup for a left single-stage laparoscopic orchiopexy. A 5-mm radial dilating trocar is placed at the umbilicus. Two 3-mm working ports are placed lateral to the rectus muscles just inferior to the umbilicus. Care is taken to avoid injury to the epigastric vessels. In the event a larger port is needed to accommodate a clip applier, a 5-mm trocar would be used on the contralateral side to ligate the testicular vessels. A 10-mm scrotal port is placed in the final stage of the case when the mobilized intra-abdominal testicle is delivered into the scrotum.

Access into the peritoneum may be achieved via an open Hasson fashion at the umbilicus. Alternatively, Veress needle access to establish pneumoperitoneumin has been shown to be safe and efficacious in children of all ages (21). A 5-mm hidden infraumbilical incision is made in the skin, and scissor dissection is performed at approximately 15- to 20-degree cephalad angle through the umbilical fascia into the underlying adherent peritoneum.

For the umbilical camera port, a 5-mm Step trocar will accommodate a 5-mm camera with a 0-degree lens. The child is placed in Trendelenburg position, and the abdomen is insufflated at 1 to 2 L per minute to a pressure of 10 to 12 cm H_2O. General survey of the abdomen is undertaken, inspecting the peritoneal structures for injury that might have occurred during port placement. Next, attention is focused on the evaluation of the pelvis. If an instrument is needed to aid in the inspection, a 5-mm port is placed on the ipsilateral side of the nonpalpable testis, lateral to the rectus and just caudal to the level of the umbilicus. An atraumatic instrument may then be used to sweep the bowel cephalad. Placement of an additional trocar on the contralateral side (lateral to the rectus and just caudal to the umbilicus) is reserved for the need of an additional working port.

In the case of unilateral undescended testicle, the internal ring of the descended testicle is examined first to gain an appreciation of the anatomy. Possible findings on inspecting the affected side of the “nonpalpable” testicle may include blind-ending vessels, cord structures entering the internal ring, or an intra-abdominal testis. Note the status of the processus vaginalis; most undescended testicles are associated with a patent processus.

Blind-Ending Testicular Vessels

Blind-ending gonadal vessels indicate the absence of a testicle. This is the result of in utero testicular torsion that is either an intra-abdominal or intrascrotal event. Vessels will have a “horse tail” appearance; they diverge, do not exit the internal ring, and do not supply obvious testicular tissue (Fig. 101.3). If found during exploration, no further investigation is warranted and the procedure is terminated. It is important to note that the finding of a blind-ending vas deferens during laparoscopy is insufficient to conclude the absence of testicular tissue. Further cephalad inspection toward the aortic origin of the gonadal vessels is then necessary.

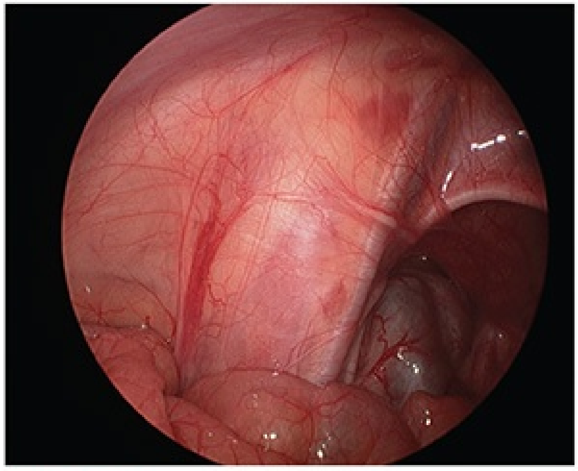

FIGURE 101.3 Finding blind-ending and divergent testicular vessels is evidence of a vanishing testicle.

Cord Structures Entering the Internal Ring

Cord structures may be visualized entering a closed internal ring or a patent processus vaginalis (Fig. 101.4). In the instance of a closed internal ring, a groin or scrotal exploration may be performed. If a patent processus vaginalis is present, the laparoscope may be used to inspect the inguinal canal via an antegrade approach. Alternatively, gentle manual retrograde pressure can be placed over the inguinal canal in an attempt to push groin contents (viable testicle versus nubbin) intra-abdominally. In the instance of a nubbin or testicular remnant, laparoscopic orchiectomy is performed. This is accomplished by either clipping or dividing the cord contents or using a 5-mm instrument designed to seal and divide smaller vessels (i.e., LigaSure or harmonic scalpel). The specimen is grasped and removed from the contralateral 5-mm port. This incision can be widened as needed by spreading the fascia with any clamp while under direct vision from the camera port.

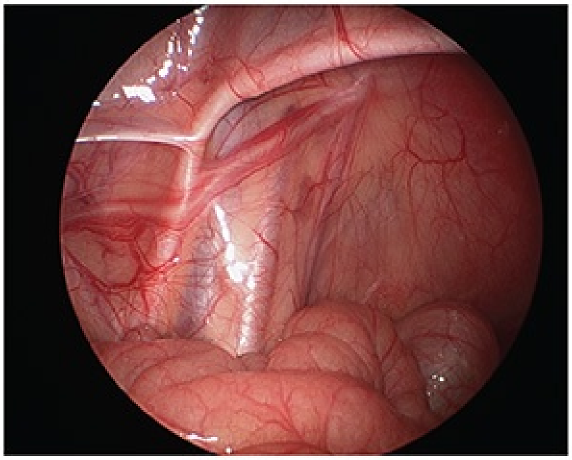

FIGURE 101.4 Laparoscopic view of the inguinal ring with normal cord structures exiting the internal ring.

Intra-abdominal Testis

There are three minimally invasive reconstructive options to address an intra-abdominal testicle: (a) primary laparoscopic orchiopexy, (b) one-stage laparoscopic Fowler–Stephens orchiopexy, and (c) two-stage laparoscopic Fowler–Stephens orchiopexy. Laparoscopic orchiectomy is reserved for an intra-abdominal nonviable testis (atrophic nubbin) or a testis that cannot be brought into the scrotum based on an extreme ectopic location or limiting vas or vessel length.

The initial measured distance of the testicle from the internal ring will determine which laparoscopic approach should be utilized and is therefore a predictor of success. “Peeping testes” or those located in close proximity to the internal ring (<2 cm away) can usually be mobilized into the scrotum in a single stage without dividing the testicular vessels (Fig. 101.5). It is important to counsel parents that intra-abdominal ectopic testes and those located >2 cm from the internal ring are at increased risk for surgical failure.

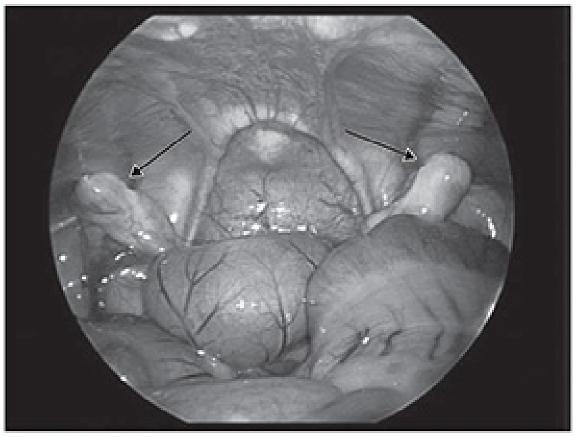

FIGURE 101.5 Bilateral intra-abdominal “peeping” testicles at the internal rings in a 6-month-old with nonpalpable gonads. Bilateral single-stage laparoscopic orchiopexies were performed.

Single-Stage Laparoscopic Orchiopexy

Following abdominal access, insufflation, and additional trocar placement, as outlined earlier, attention is focused on the ipsilateral testicle and internal ring. Fig. 101.6 demonstrates the surgical “map” needed to mobilize a triangular flap of peritoneum demarcated by the testicular vessels laterally and vas deferens medially. The preliminary goal is to create two continuous peritoneotomies parallel to the testicular vessels and vas in order to mobilize the testicle on a well-vascularized peritoneal pedicle.

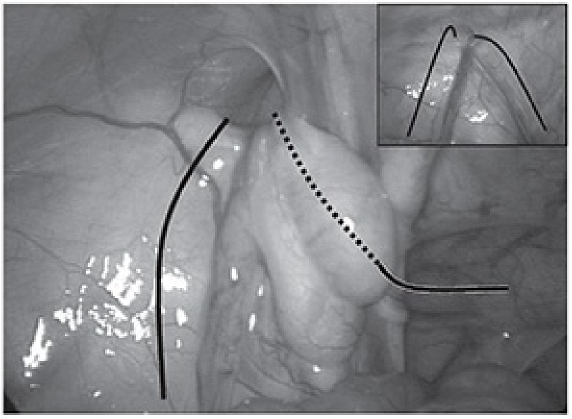

FIGURE 101.6 A left intra-abdominal testicle in an 8-month-old boy at the internal ring. The *dark lines* represent where peritoneotomies are made parallel to the testicular vessels (lateral) and vas deferens (medial) in order to mobilize the testicle on a vascularized peritoneal pedicle flap. The *insert* shows the same landmarks when a nonpalpable intracanicular testicle is milked into the abdomen and then mobilized via laparoscopic orchiopexy.

The testicle, epididymis, and extent of vasal descent distally into the inguinal canal are evaluated. It is critical from the onset to define the gubernacular attachments and identify a long-looping vas, if present. Scissors are used in the preliminary dissection. Care must be taken to avoid use of electrocautery in proximity to the vessels and vas. The first peritoneotomy is made lateral to the testicular vessels at the most proximal position. The incision is directed toward the internal ring. Often after the first incision, pneumoperitoneum will diffuse into the plane between the peritoneum and pelvic side wall. In this regard, CO_2 can aid in isolating the peritoneum to be dissected.

The second line of dissection will again begin at the level of the internal ring distally but will parallel the vas medially. Care is taken not to injure the iliac vessels and ureter that lie beneath the vas. It is also critical that dissection is not performed within the distal triangular area enclosed by the gonadal vessels and vas (Fig. 101.7). Critical collateral microvasculature within this flap will flow from the vasal artery to the testicle and should be maintained if possible. This is especially relevant if a single-stage Fowler–Stephens orchiopexy is performed; dividing the testicular vessels and interrupting collateral blood flow will invariably lead to testicular atrophy. Widely mobilizing the peritoneal flap laterally and medially leaves only the distal gubernacular attachments. A window is created distally, allowing the gubernaculum to be divided while visualizing the course of the vas deferens. An indication that dissection has maximized the flap length is that the testicle can reach the contralateral internal ring without tension. The ipsilateral ring is not closed since there is not an increased risk for a clinically significant hernia to develop. The patent processus is ablated by the peritoneal incisions, division of the gubernaculum, and, if necessary, incision of the anterior peritoneum. Subsequently, peritoneal regrowth obliterates the previously patent tract.

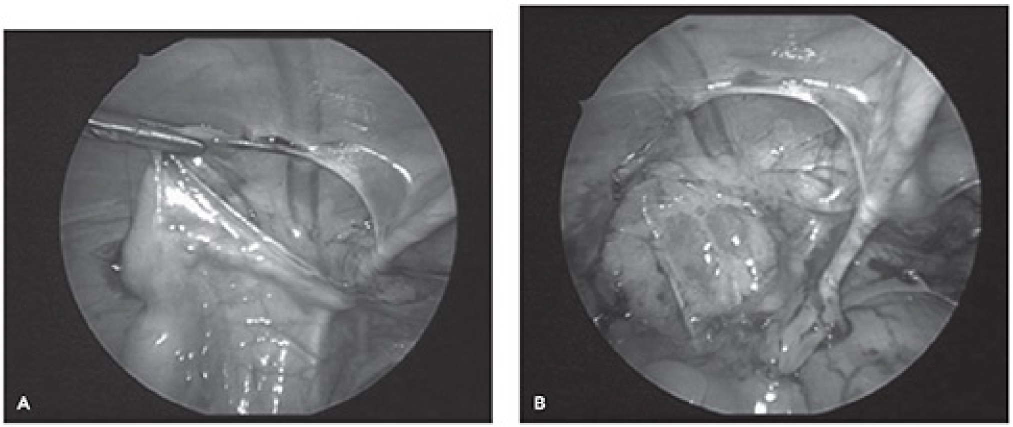

FIGURE 101.7 After lateral mobilization, medial dissection follows the course of the vas deferens (**A**). Collateral paravasal blood supply to the testicle is visualized. Cephalad traction following release of the distal gubernacular attachments (**B**) demonstrates the extent of the peritoneal flap and clarifies the boundaries where the neoinguinal hiatus is to be created between the inferior epigastric vessels and the medial umbilical ligament.

Various methods to deliver the testicle into the scrotum have been described. The authors feel the testis is most safely and effectively delivered to the scrotum using a radially dilating 5- or 10-mm trocar with assistance of laparoscopic instruments. A 12-mm ipsilateral scrotal incision is first made, and a subdartos pouch created. A 5- or 10-mm Step trocar (depending on testicular size) is then placed via the scrotum into the peritoneum under direct visualization from the laparoscope. This creates the neoinguinal hiatus. Care is taken to place the instrument over the pubis and between the medial umbilical ligament and epigastric vessels. After the instrument is passed through the scrotum, the Foley catheter is checked for hematuria. A bladder injury, which is very rare, would most likely occur during this step of the procedure. Proper placement of the instrument in the position described earlier should minimize the risk of this complication (Fig. 101.8). The 5- or 10-mm trocar obturator, depending on the size of the testicle, is then inserted, creating the neoinguinal hiatus. A locking grasper is introduced into the abdomen through the scrotal trocar, and the testicle is grasped at the gubernaculum and then delivered into the scrotum (Fig. 101.9). It is imperative for the surgeon to personally monitor the tension on the cord during scrotal delivery to ensure the vessels are not avulsed.

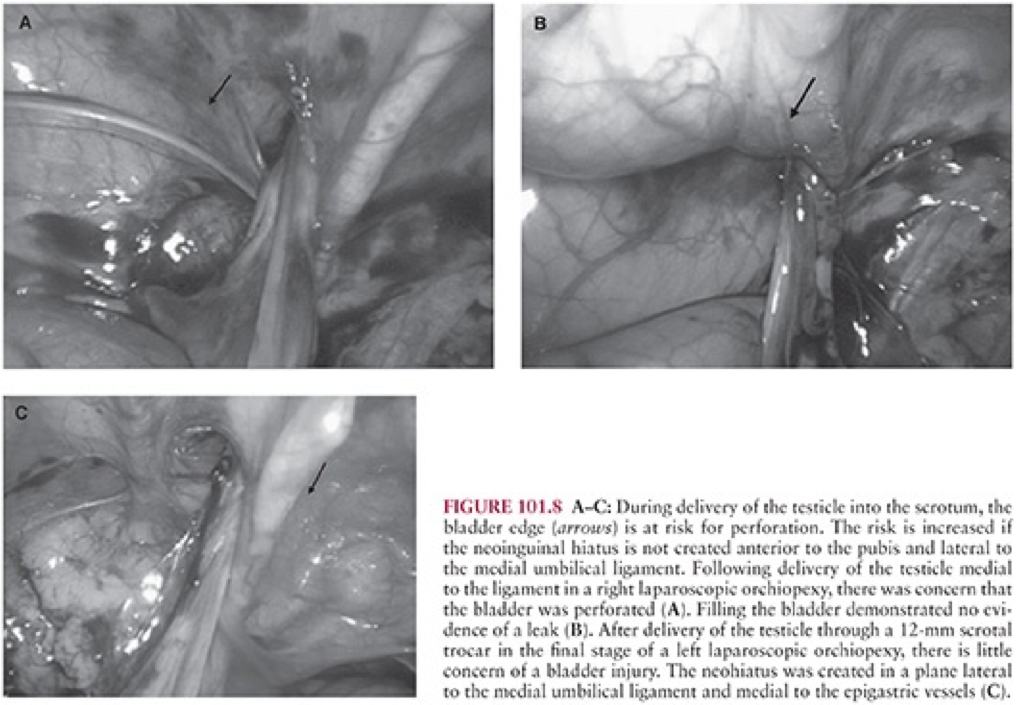

FIGURE 101.8 **A–C:** During delivery of the testicle into the scrotum, the bladder edge (*arrows*) is at risk for perforation. The risk is increased if the neoinguinal hiatus is not created anterior to the pubis and lateral to the medial umbilical ligament. Following delivery of the testicle medial to the ligament in a right laparoscopic orchiopexy, there was concern that the bladder was perforated (**A**). Filling the bladder demonstrated no evidence of a leak (**B**). After delivery of the testicle through a 12-mm scrotal trocar in the final stage of a left laparoscopic orchiopexy, there is little concern of a bladder injury. The neohiatus was created in a plane lateral to the medial umbilical ligament and medial to the epigastric vessels (**C**).

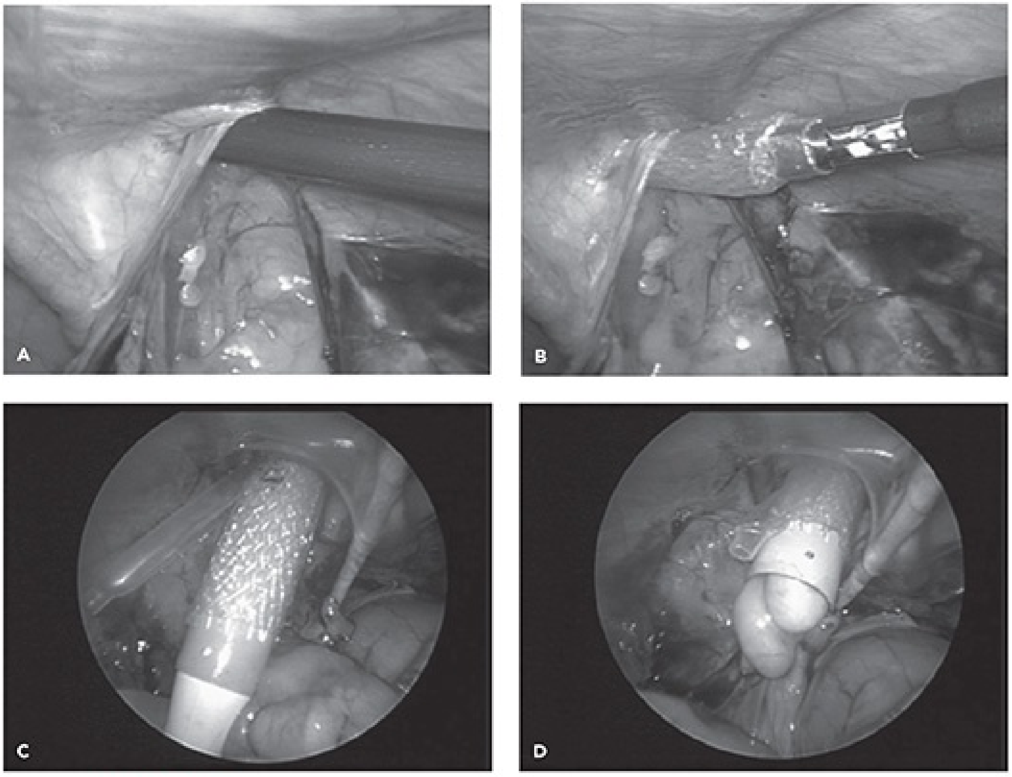

FIGURE 101.9 Delivering the testicle into the scrotum requires developing a neohiatus (A–C) to facilitate passage of the testicle, epididymis, and cord structures into the scrotum without resistance. This technique minimizes the risk of an avulsion injury (D).

After delivering the testicle into the scrotum, if there is tension and/or additional length is needed, further dissection can be carried out laterally and cephalad toward the kidney. An option at this point is to divide the peritoneum overlying the testicular vessels to provide extra cord length and release any remaining tension (Fig. 101.10). If incising the peritoneum does not achieve sufficient length, consideration can be given to dividing the testicular vessels, therefore performing a one-stage Fowler–Stephens orchiopexy. The contralateral working port must be 5 mm in order to accommodate a clip applier. Consideration must be given to the higher risk of testicular atrophy after a one-stage Fowler–Stephens procedure. When the testicle lies tension-free in the scrotum, the orchiopexy can be completed (Fig. 101.11). The testicle is harnessed in the dartos pouch, and the scrotal skin is closed by any of the preferred technique(s) utilized by the surgeon.

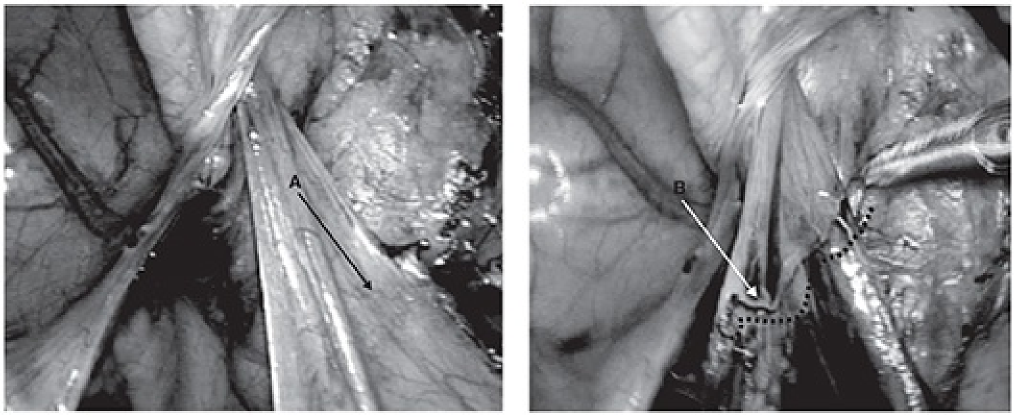

FIGURE 101.10 Delivering the testicle into the scrotum provides the traction and assistance of a "third arm." If there is tension and/or additional length is needed, further dissection can be carried out laterally and cephalad. The peritoneum overlying the testicular vessels (*A*) may also be divided (*B*) to release tension and provide extra cord length.

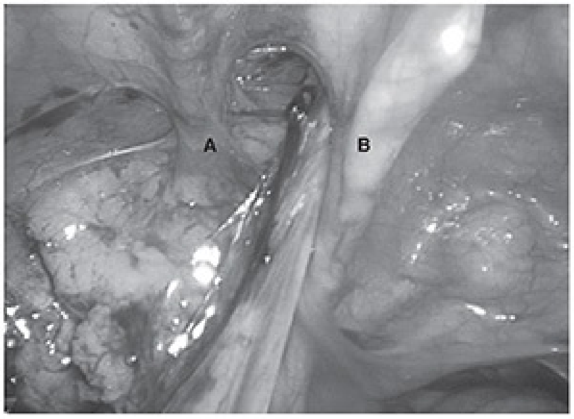

FIGURE 101.11 Antegrade view of a left neoinguinal hiatus created between the inferior epigastric vessels (*A*) and the medial umbilical ligament (*B*). The testicle is fixed to the scrotum after maximal length on the cord has been reached without residual tension.

The abdomen is surveyed a final time and the pneumoperitoneum pressure is lowered. Any occult bleeding should be identified and addressed at this time. While maintaining pneumoperitoneum, the two lateral ports are removed sequentially and inspected for bleeding. Pneumoperitoneum is evacuated through the umbilical port. The umbilical trocar and camera are removed while inspecting for bleeding. The umbilical port fascia is closed with an interrupted 2-0 Vicryl; this can be performed with a Carter-Thomason device if necessary. The skin is then closed in a subcuticular fashion, and dressings or skin glue are applied.

Two-Stage Fowler–Stephens Procedure

As a general rule, the further the intra-abdominal testicle lies from the internal ring (i.e., >2 cm), the higher the likelihood that a staged procedure is necessary. Staging the procedure will enable delivery of the testicle into the scrotum without tension and at a decreased risk for atrophy. This may be accomplished by ligating the testicular vessels by using a 5-mm clip applier through the contralateral port (Fig. 101.12). A laparoscopic second-stage Fowler–Stephens orchiopexy is performed approximately 6 months later, when collateral blood flow from the deferential artery has matured.

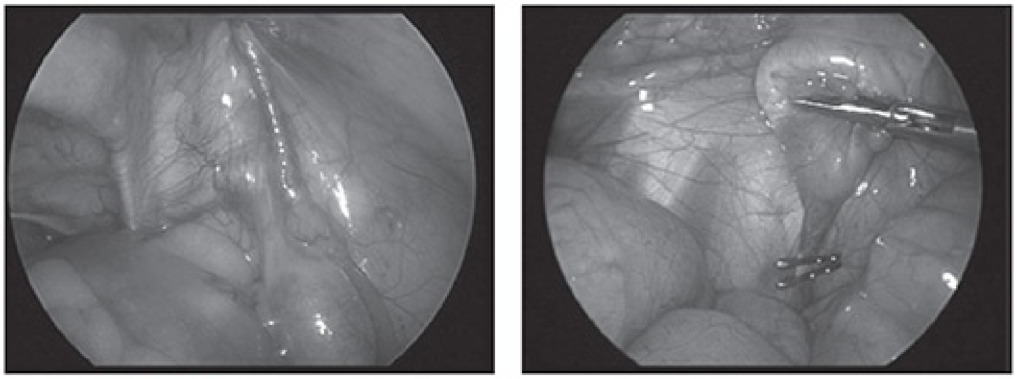

FIGURE 101.12 A right intra-abdominal testicle in a 9-month-old boy was found >2 cm from the internal ring (**left**). The testicular vessels were clipped in the first stage of a two-stage Fowler–Stephens reconstruction (**right**). Note that clips are applied without dissecting the peritoneal attachments free from the vessels.

Inguinal Orchiopexy

A 2- to 3-cm incision along the lines of Langer is made in a groin crease one-third of the way between the pubic tubercle and the anterior superior iliac spine (Fig. 101.13). The incision is carried through subcutaneous fat and Scarpa fascia to the level of the anterior aspect of the inguinal canal using Metzenbaum scissors. Overlying fat and fascia are cleared off the external oblique fascia, allowing visualization of the shelving edge. The external ring is visualized and the anterior aspect of the inguinal canal is incised by nicking the fascia with a scalpel blade; an ectopic testicle may be visualized exiting through the ring. An incision placed too far medial makes cord identification more difficult, whereas an incision too far lateral inhibits fascial closure. Metzenbaum scissors with the tips facing upward are inserted into the nick and used to spread the adjacent tissue away while taking care to identify and preserve the underlying ilioinguinal nerve. The roof of the inguinal canal is then opened along the course of its fibers downward toward and through the external ring. The spermatic cord is identified, elevated, and dissected free of the anterior cremaster fibers using blunt dissection and DeBakey forceps.

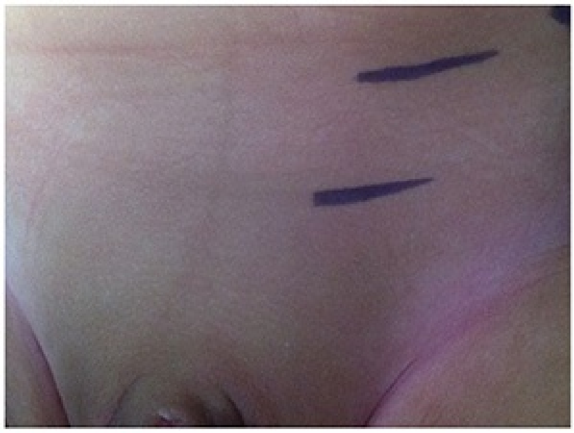

FIGURE 101.13 Incision for left inguinal orchidopexy is created one-third of the distance between the pubic tubercle (*lower line*) and the anterior superior iliac spine (*upper line*).

If no cord structures are identified, attention is turned to the level of the internal ring, and by application of abdominal pressure and retraction in the internal ring frequently, a testicle may be identified just inside the internal ring. If no testicle is identified, the peritoneum is opened and a search is performed for either a testicle or a blind-ending vas and vessels. Blind-ending spermatic vessels must be identified to confirm absence of a testicle as a blind-ending vas does not guarantee testicular absence.

After identification of the testicle and spermatic cord in the canal, the gubernaculum is divided either sharply or with electrocautery. Placement of a hemostat on the proximal end for traction provides a means of manipulating the testicle and cord structures safely. Care must be taken at this point to avoid a long-looping vas deferens that sometimes extends distally. Elevation of the cord permits blunt sweeping dissection of the inferior cremaster fibers proximally to the level of the internal ring. By placing a retractor in the internal ring and pulling the cord and attached peritoneum medially, the surgeon gains access to the retroperitoneal space along the lateral aspect of the internal ring, which is enveloped in the endopelvic fascia. The cord and peritoneum may then be swept anterior and medial with blunt dissection in the retroperitoneal space.

The intermediate stratum, an extension of connective tissue that envelopes the spermatic vessels and vas deferens in the retroperitoneum, is located between the inner striatum (connective tissue of the peritoneum) and the outer striatum (transversalis fascia). As the vas joins the vessels in the inguinal canal, the fibers of the intermediate stratum attenuate and the structures (vas, vessels, processus vaginalis) are enveloped by the internal spermatic fascia, which is an extension of the transversalis fascia from the floor of the inguinal canal. To free the remaining anterior and medial retroperitoneal attachments to the spermatic vessels and vas deferens, the internal spermatic fascia must be divided, allowing separation of the processus and contiguous peritoneum from the vas and vessels and complete access to the retroperitoneum (Fig. 101.14).

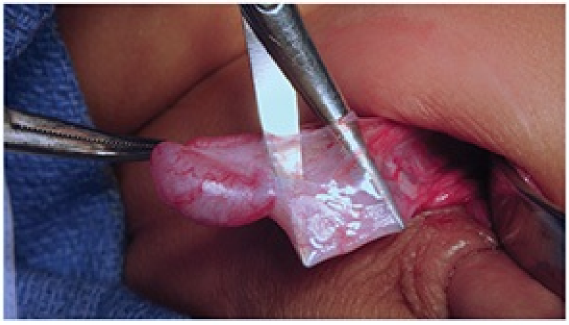

FIGURE 101.14 Isolation of cord structures during orchiopexy.

With a nonpatent processus vaginalis, a hemostat providing anterior traction on the tip of the peritoneal reflection permits dissection of the underlying cord from the internal spermatic fascia binding it to the peritoneum. With a patent processus vaginalis, the posterior cord is exposed, the internal spermatic fascia is swept off the cord structures, and the processus vaginalis is freed to the level of the peritoneum. The processus vaginalis is incised and the edges readily dissected away from the underlying cord. The processus is twisted and ligated at the level of the internal ring with a 3-0 or 4-0 Vicryl suture.

The anterior and medial retroperitoneal attachments to the cord may be approached by placing a retractor anterior to the vessels in the internal ring, allowing the bands of the retroperitoneal fascia to be bluntly dissected from the vessels to obtain increased cord length. The beginning of the retroperitoneum is marked by the divergence of the vas medially and inferiorly. The circumferential dissection of the vessels can be extended in the retroperitoneum up to the level of the renal hilum if the need arises to gain additional cord length so the testicle can reach the scrotum without tension. True skeletonization of the vas and vessels should be avoided as this can lead to testicular atrophy. The limiting factor on length is most often the spermatic vessels rather than the vas deferens (Fig. 101.15). To gain additional length, a Prentiss maneuver can be performed by using a right angle to puncture through the floor of the inguinal canal near the pubic tubercle and then passing the testicle directly under the transversalis fascia toward the scrotum, in effect moving the course of the vessels toward the midline with alignment of the internal and external rings.

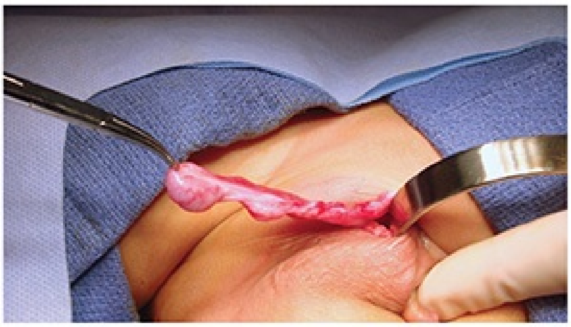

FIGURE 101.15 After dissection, adequate spermatic cord length is demonstrated.

With an absent testicle, blind-ending vas and vessels may be encountered in the inguinal canal. The tubular structures in the canal must be traced proximally to the internal ring, where the divergence of the vas and vessels helps the surgeon positively identify the spermatic vessels. With visualization of blind-ending spermatic vessels, no further exploration for a testis is indicated. However, a blind-ending vas deferens is not sufficient reason to stop the exploration because there are patients with a wide separation of the vas and an intra-abdominal testis. When no spermatic cord structures are identified in the inguinal canal, the dissection is carried to the internal ring and into the retroperitoneum. If no structures are identified, the peritoneum is opened and the testicle or blind-ending spermatic vessels are sought.

Repeat inguinal exploration for a failed orchiopexy is associated with scar tissue surrounding the testicle and spermatic cord causing adherence to the underside of the external oblique fascia. Following the inguinal incision, the testicle should be identified and freed from surrounding scar tissue. Once this is accomplished, the cord can usually be freed along its posterior aspect extending through the inguinal canal. No attempt is made to dissect the cord from the scar extending along its anterior surface and the overlying external oblique fascia. By cutting the fascia along the medial and lateral sides of the cord and then connecting these incisions above the internal oblique muscle, a strip of fascia is left attached to the cord as described by Cartwright et al. (Fig. 101.16). The peritoneum may then be opened and the spermatic vessels freed as described earlier. At the peritoneal level, there is rarely any significant scar tissue.

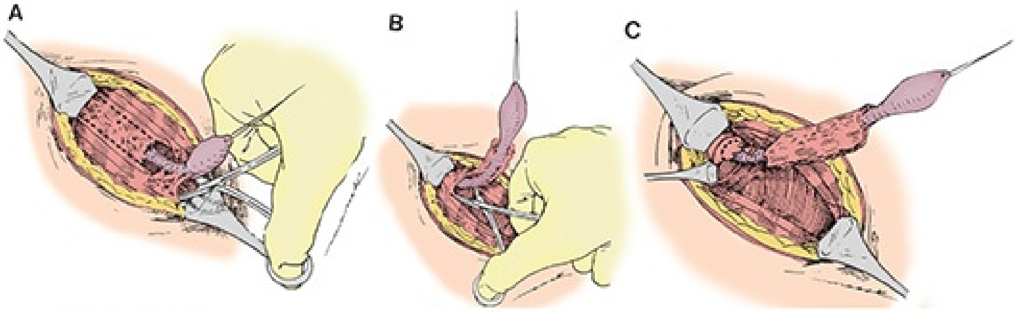

FIGURE 101.16 Reoperative orchiopexy demonstrating external oblique fascial incisions lateral and medial to the cord structure. The adherent scar tissue is dissected with the spermatic cord and no attempt is made to dissect the spermatic cord from the scar. **A:** Demonstrates a plane being dissected beneath the testicle and spermatic cord and the lines of incision in the fascia and surrounding scar lateral and medial to the cord. **B:** Demonstrates dissection proximally to the level of the internal oblique muscle. **C:** Demonstrates the dissection after a transverse incision has been made connecting the medial and lateral incisions above the internal oblique muscle. (Reprinted with permission from Cartwright PC, Velagapudi S, Snyder HM III, et al. A surgical approach to reoperative orchiopexy. *J Urol* 1993;149:817–818. Copyright © 1993 American Urological Association, Inc. Published by Elsevier Inc. All rights reserved.)

Multiple methods have been described for fixing the testis to the scrotum, although the subdartos pouch is the authors' preferred method. Following a transverse incision in the hemiscrotum (Fig. 101.17), a pocket for the testicle is created by dissecting the scrotal skin superiorly and inferiorly from the adherent underlying dartos using Ragnell orchiopexy scissors (Fig. 101.18). Care must be taken not to develop the pouch too lateral or too inferior because this could result in an ectopic testis location. The testicle is exposed by opening the tunica vaginalis. A testicular biopsy is not routinely indicated for prepubertal patients. Once adequate cord length has been obtained, the testicle is passed down from the inguinal incision using a hemostat attached to the gubernaculum. The testicle is brought through the dartos and placed in the pouch, taking care to ensure correction testicular orientation and avoid torsion of the cord. A small portion of the parietal tunica vaginalis is secured to the dartos inferiorly and superiorly with an absorbable suture, allowing for scarring and fixation. The scrotal skin is then closed with subcuticular sutures (Fig. 101.19). For the inguinal incision, the fascia is closed with interrupted 3-0 Vicryl suture, taking care not to close the external ring too tightly, followed by closure of the subcuticular tissue with 4-0 Vicryl and skin with absorbable suture. For postoperative pain control, anesthesia can administer a caudal block, or a local nerve block with 0.25% Marcaine can be performed by the surgeon just prior to closure.

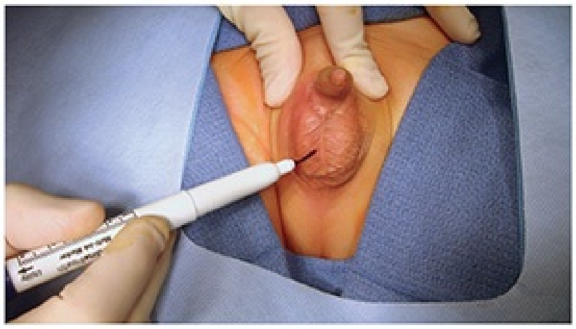

FIGURE 101.17 Incision for subdartos pouch. The testis is brought into the subdartos pouch in a tension-free manner.

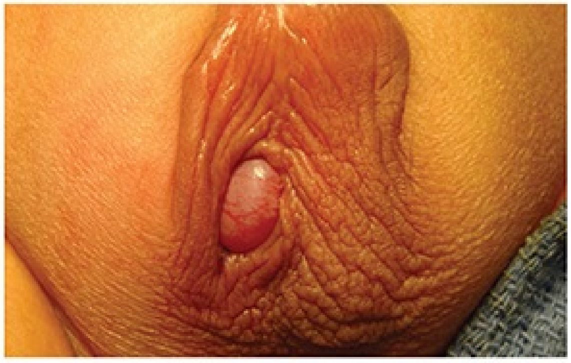

FIGURE 101.18 Creation of dartos pouch using Ragnell orchiopexy scissors.

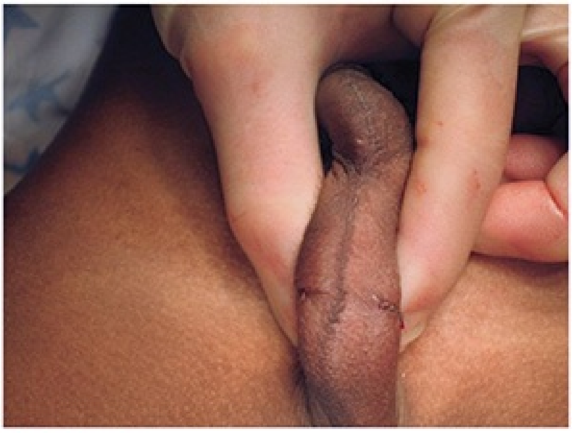

FIGURE 101.19 Successful orchiopexy shows both testes in the scrotum.

Scrotal Orchiopexy

In the 1980s, a single incision, transscrotal technique was introduced by Bianchi and Squire (22).

Benefits of using this approach include reduced operative times, less postoperative pain, and an esthetically pleasing single scrotal wound. Initial concern focused on a high incidence of hernias or hydroceles if ligation of the sac was not high enough, or that reascent may occur if the proximal attachments were not divided. The scrotal incision orchiopexy has been shown to be highly successful in children with palpable undescended testis that can be brought down following induction of anesthesia to the scrotum with caudal traction by the surgeon (23). Patency of the processus vaginalis is not a contraindication to performing scrotal approach orchiopexy if the testis can be brought down to the scrotum preoperatively. The processus vaginalis is dissected free of cord structures and, if patent, then high suture ligation is performed. Testicular fixation is performed as described earlier.

Outcomes

Successful therapy, as defined by a viable testis positioned in the scrotum, is dependent on the preoperative anatomic position of the testis as well as operative technique. In a meta-analysis, Docimo (24) reported success rates associated with the preoperative anatomic position of the testis, including 74% for abdominal, 82% for peeping, 87% for canalicular, and 92% for those distal to the external ring. The success rate of various open techniques included 89% for standard inguinal orchiopexy, 67% for Fowler–Stephens, 77% for staged Fowler–Stephens, 81% for transabdominal, 73% for two-stage, and 84% for microvascular (24). All of these results suggest an advantage to maintaining intact vessels where possible, and when performing a Fowler–Stephens approach, staging has been shown to yield higher success rates (25). In a large multi-institutional analysis, Baker et al. (26) reported excellent laparoscopic success rates superior to that of historical open orchiopexy and no significant difference in success or complication rates between low- and high-volume centers.

Paternity rates among men who had attempted to father children were 65%, 90%, and 93% in men with bilateral cryptorchidism, unilateral cryptorchidism, and normally descended testicles, respectively (27). If only one testis is undescended, the sperm count will be subnormal in 25% to 33% and the serum FSH concentration will be slightly elevated (28,29). The presence of these abnormalities suggests that both testes are abnormal, perhaps congenitally, although only one fails to descend. If both testes are undescended, the sperm count usually will be severely subnormal and the serum testosterone may be reduced (29).

Complications

Retraction is the most common complication of orchiopexy and usually occurs secondary to an incomplete initial dissection and tension on the testicle. It is possible that some cases of retracted testicle after an orchiopexy occur because of dislodgement of the testis from the scrotum. To prevent this possibility, straddle toys are avoided for at least 4 weeks following the operation. Older children are instructed to avoid bicycles and team sports for 4 weeks postoperatively.

The most significant complication is testicular atrophy, which occurs in 1% to 2% of cases following orchiopexy, although complete devascularization of the testis is rare. The dissection of the testicular vessels and/or postoperative swelling and inflammation can result in ischemic injury with subsequent testicular atrophy. The failure rate with orchiopexy is 8% for distal undescended testes and 26% for intra-abdominal undescended testes (24). Other potential complications include ascent of the testis requiring reoperative orchiopexy, infection, bleeding, ilioinguinal nerve injury, or damage to the vas deferens.

Complications associated with laparoscopic orchiopexy compare favorably to that of open inguinal approach. In a large multi-institutional review of laparoscopic orchiopexy, a major complication rate of 3.0% and a minor complication rate of 2.0% were reported (26). Major complications that have been reported include acute testicular atrophy, bowel perforation, cecal volvulus, vascular injury, bladder perforation, ileus, laceration of the vas, testicular vessel avulsion, and wound dehiscence/infection.

The prevention of complications associated with laparoscopy starts with proper positioning and padding to reduce the risk of neuromuscular injuries. Although injuries are less likely to occur with pelvic laparoscopy, extremes in table positioning are often necessary. Close attention to placement of straps and/or tape and adequate padding should limit positioning-related injuries. As in adults, abdominal visceral injuries related to access are encountered; however, an understanding of the unique anatomic aspects of the pediatric abdominal wall can decrease these risks. The pediatric abdomen requires less force for entry, so penetration injury to the abdominal viscera can easily occur. The smaller pediatric working space also sets up the potential for injury to the visceral structures from the laparoscopic working elements.

An appreciation of the anatomic landmarks within the pelvis will aid in avoiding laparoscopic complications. During testicular mobilization, care must be taken to avoid injury to the vas, testicular, femoral, and iliac vessels as well as the ureter. When mobilizing the vas on the medial aspect of the peritoneal flap, these structures lie directly posterior and medial. In general, complications can be limited by careful intra-abdominal mobilization, using limited cautery in short bursts, and execution of meticulous technique. The laparoscopic approach facilitates this by allowing extensive and high retroperitoneal mobilization of the testicular vessels in an atraumatic manner.

HYDROCELE/HERNIA

A hydrocele consists of a collection of fluid in the tunica vaginalis surrounding the testicle. In children, the vast majority are associated with a patent processus vaginalis that permits flow of peritoneal fluid into the tunica vaginalis (communicating hydrocele). An indirect inguinal hernia forms when bowel or any other tissue from the abdominal cavity protrudes into the patent processus. Between 0.8% and 4.4% of newborns and up to 30% of premature infants have an inguinal hernia. Boys are 6 times more likely than girls to have a hernia and right-sided hernias occur twice as frequently as left-sided hernias, with bilateral hernias occurring about 10% of the time.

Diagnosis

Children with a hydrocele or hernia present with swelling in the groin and scrotum/labia. This swelling can be persistent or intermittent and may not be directly observed by the physician. Often, it is noted by the parents only when the child is crying or straining and the intra-abdominal pressure is elevated. In this case, the diagnosis depends on a reliable history from the parents describing the intermittent groin and scrotal swelling. Older children may be examined while standing and performing a Valsalva maneuver to increase the intra-abdominal pressure. Rarely, children will present with large abdominoscrotal hydroceles that cross the internal inguinal ring and contain an intra-abdominal component resulting in a palpable abdominal mass.

With increasing size of the hydrocele, the testicle becomes more difficult to palpate and often is not palpable. Usually, a hydrocele becomes narrow at the level of the internal ring, and the examiner is able to detect this narrowing and get above the swelling. With a hernia, the swelling extends through the internal ring. The fluid in a hydrocele sac will transilluminate; however, bowel can also be transilluminated, making this a nonspecific finding for either a hydrocele or a hernia.

Ultrasonography may help define the testicle and rule out any testicular pathology as well as help differentiate a hydrocele from a hernia.

Surgical Technique

A similar inguinal incision is made for indirect hernias or communicating hydroceles as previously described in surgical technique for inguinal orchidopexy. After the inguinal canal is opened, the cremaster fibers may be bluntly spread off the anterior aspect of the spermatic cord. The bulging shiny hernia sac or patent processus vaginalis, which is typically located anterior and medial, is identified and grasped with a hemostat. By elevation of the hernia sac, the cord is brought up and freed from surrounding cremaster attachments, permitting the surgeon's finger to be placed beneath the entire spermatic cord and hernia sac. Extensive dissection of cremasteric fibers need not be performed. The sac is teased off the underlying cord by breaking apart the internal spermatic fascia that encases the cord structures and the hernia sac. As this is done, the cord structures are separated from the hernia sac by passing a hemostat from lateral to medial and spreading at a 90-degree angle to separate cord from hernia sac. When the cord structures are completely freed, the sac is transected and then dissected up to the internal inguinal ring. It is important to identify the internal spermatic fascia and break this down so that when the sac is twisted and ligated, the cord structures will not become incorporated.

The hernia sac is twisted and high ligation is performed with two 3-0 or 4-0 Vicryl sutures and divided close to the level of the internal ring. The distal sac or hydrocele is then delivered along with the testicle into the wound, and the sac is opened down to the level of the testicle, taking care not to injure the cord structures. The authors routinely evert and sew the hydrocele sac behind the cord or testis in a Bottle technique with an absorbable suture to prevent the possible reformation of the hydrocele. Repair of the dilated internal inguinal ring may be required and is accomplished by approximation of the transversalis fascia to itself at the level of the internal ring, taking care not to strangulate the cord. The conjoined tendon may also be sutured to the shelving edge of the inguinal ligament. The testicle is then drawn back into the scrotum with traction on the scrotal skin and gubernaculum. The external oblique aponeurosis and wound are then closed as described earlier for inguinal orchiopexy.

Outcomes

Open inguinal hernia repair with high sac ligation has excellent results, with an approximately 99% success rate (30,31). Recurrence after herniorrhaphy may be attributed to a failure to ligate the sac high enough at the internal ring, injury to the floor of inguinal canal because of operative trauma, failure to close the internal ring in girls, or postoperative wound infection and hematoma (32).

Complications

Recurrence or persistence of the hernia or hydrocele may occur if the patent processus is not well ligated and occurs in approximately 1% of cases. Injury to the underlying spermatic and/or vas deferens vessels may result in testicular atrophy, which has been reported in up to 1% to 2% of cases (33). Displacement of the testicle to an extrascrotal location may occur after surgery. To prevent this complication, every hydrocele and hernia repair should be concluded by confirmation of the testis location in its normal dependent scrotal position.

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CHAPTER 102 PEDIATRIC LAPAROSCOPIC AND ROBOTIC PYELOPLASTY

PASQUALE CASALE AND WALID A. FARHAT

Historically, open pyeloplasty has been the standard treatment for congenital or acquired ureteropelvic junction (UPJ) obstruction in adults and children, with overall success rates of 90% to 100% (1–3). Although endopyelotomy (4) and retrograde dilation (5) are alternative methods of managing UPJ obstruction in children (6), the success of these two procedures is inferior to that reported for conventional dismembered pyeloplasty (7). Advances in technology have played a significant role in the therapeutic management of UPJ obstruction and have enabled the introduction of laparoscopic and robot-assisted laparoscopic pyeloplasty over the last few years. Continued interest in minimally invasive treatment for UPJ obstruction has inspired new questions about the optimal laparoscopic approach for treating this disease.

Laparoscopic pyeloplasty was introduced in adults in 1993 (8,9). In the initial reports, the operative time ranged from 3 to 7 hours, but the procedure has gradually gained in popularity and acceptance with a reported success rate of over 95% (10–16). Yeung et al. (15) reported their initial experience with retroperitoneal laparoscopic pyeloplasty in 13 children, one of who required open conversion. The mean operative time was 143 minutes (range 103 to 235 minutes). El-Ghoneimi et al. (16) reported their experience with 50 retroperitoneal laparoscopic pyeloplasties in children aged between 22 months and 15 years. Conversion to open surgery was necessary in four cases due to technical difficulties during suturing. Mean hospital stay was 2 days, and return to full activities occurred within 5 days of surgery. The longer time needed for the retroperitoneal approach is almost certainly related to the limited working space that renders suturing more difficult.

DIAGNOSIS

Approximately 1% of prenatal ultrasounds detect hydronephrosis in the fetus. In 50% of these cases, UPJ obstruction causes the condition. UPJ obstruction is more common in males and affects the left kidney more often than the right. About 10% to 30% of cases occur in both kidneys (bilaterally) (11). Congenital abnormalities are the most common cause of UPJ obstruction in children. The condition often results from an abnormality in the muscles that surround the UPJ causing an intrinsic narrowing. It may also be caused by an abnormality in the structure or position of the ureter such as a high insertion onto the renal pelvis. Lower pole renal blood vessels crossing over the ureter can cause an obstruction as well. Other etiologies of UPJ obstruction are compression of the ureter caused by inflammation, retroperitoneal fibrosis, kidney stones, or scar tissue from previous surgery to correct UPJ obstruction. Symptoms of UPJ obstruction are typically seen in the older children but can be seen in infants and include the following: back or flank pain, hematuria, failure to thrive, flank mass, and/or pyelonephritis.

UPJ obstruction that causes hydronephrosis is usually diagnosed by prenatal ultrasound. Neonatal patients suspected to have this condition are evaluated for the obstruction using renal ultrasound and diuretic renography. Magnetic resonance urography has also become part of the armamentarium for radiologic imaging. In some children, a voiding cystourethrogram (VCUG) might be utilized to rule out vesicoureteral reflux as a cause of the hydronephrosis or as a concomitant finding.

INDICATIONS

Laparoscopic pyeloplasty includes two modalities of delivery: conventional laparoscopy and robotic-assisted laparoscopy. For this chapter, both modalities will be referred to as laparoscopic pyeloplasty. A section of the chapter at the end will discuss added nuances of the robotic platform.

The indications for laparoscopic pyeloplasty are similar to those for an open pyeloplasty. They encompass increasing hydronephrosis, progressive deterioration of renal function, recurrent urinary tract infection (UTI), and persistent pain. The introduction of refined instrumentation and more experience with intracorporeal suturing allows reconstructive laparoscopy to be implemented in the pediatric population, with multiple techniques of pyeloplasty described in the literature (12). One of the earliest descriptions of the transperitoneal Anderson–Hynes laparoscopic pyeloplasty in pediatric patients by Tan et al. (13) recommended that it should not be performed in children younger than 6 months of age. The advent of improved 3-mm instrumentation and laparoscopic telescopes has allowed better suture manipulation and visualization, making it feasible even in the infants younger than 6 months of age (14). The key point to performing a laparoscopic pyeloplasty in the infant is based on the geometry of the patient's body habitus. A triangle is constructed utilizing the umbilicus as the apex with the remaining points being lateral to the ipsilateral rectus muscle subcostal and at the level of the anterior superior iliac spine.

Whereas open pyeloplasty has long been described, laparoscopic pyeloplasty has only recently been reported, and long-term outcome data are still being evaluated. As laparoscopic pyeloplasty is technically challenging, this procedure was initially restricted to those medical centers with advanced laparoscopic surgeons. With increasing experience, however, laparoscopic pyeloplasty in children is more commonly being considered as the initial treatment for UPJ obstruction (17). This procedure maintains the benefits of the endoscopic approaches, including decreased postoperative pain, short hospitalization, and reduced postoperative recovery time while demonstrating success rates comparable to those of the conventional open approach (18,19).

ALTERNATIVE THERAPY

Open pyeloplasty still remains the gold standard for correcting UPJ obstruction with a high success rate done either through a flank, dorsal lumbotomy, or anterior muscle-splitting incision. Proponents of open pyeloplasty have shown that this procedure can be done without placement of an indwelling ureteral stent along with simple percutaneous drainage either by a nephrostomy tube or single Penrose drain (1–2).

Endopyelotomy and retrograde dilation are also alternative methods of managing UPJ obstruction in children. Endopyelotomies are performed in the same fashion as in adults either by a percutaneous approach or ureteroscopically in a retrograde manner (4). The long-term success rate of endopyelotomy is less than the standard open or laparoscopic approaches (4,12–14). Retrograde dilation has virtually no role in pediatrics due to its high failure rate requiring a subsequent procedure (5).

LAPAROSCOPIC SURGICAL TECHNIQUE AND STEPS

Initial cystoscopy and ureteric stenting is left to the discretion of the surgeon and may not be necessary (20,21). An indwelling Foley catheter is placed to gravity drainage.

Positioning of the patient is crucial as it facilitates optimal ergonomics for the surgeon and increased access to the operative space. For both a transperitoneal and retroperitoneal approach, the patient is placed in a lateral or semilateral decubitus position in close proximity to the posterior edge of the table, the table is flexed, the kidney rest is elevated, appropriate padding is applied, and the patient is secured with 2-inch tape and a safety belt. An option for the retroperitoneal approach described by Yeung et al. (15) is a modified semiprone position with the left flank up or a 45-degree right lateral decubitus position (for right-sided obstruction) to allow the subsequent ureteropelvic anastomosis using the right hand (for a right-handed surgeon). Another option utilized for the transperitoneal approach is to place the patient supine with a slight 30-degree rotation of the ipsilateral side. The patient is then secured to the table with 2-inch silk tape (Fig. 102.1). The table can then be rotated as needed after visualization of the intraperitoneal field. This approach can be utilized on the left side allowing the colon to stay lateral to the left kidney so a transmesenteric window is unobstructed. As far as trocar placement, a fundamental concept that is important to implement is that conventional laparoscopy is ergonomically favored by triangulation of ports, whereas the robotic platform will function better with the ports arranged in as straight a line as possible with at least 4 cm between all ports.

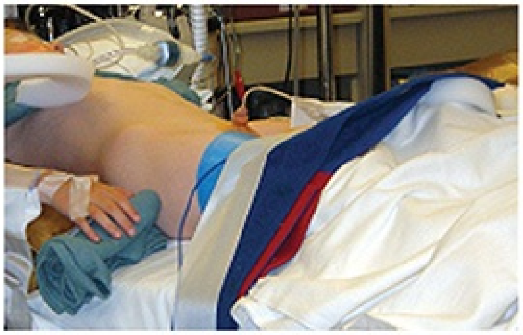

FIGURE 102.1 Supine positioning for transperitoneal approach in left-sided and bilateral cases.

Retroperitoneoscopic Approach

Appropriate placement of the trocars is of the utmost importance and three or four laparoscopic ports are inserted at the surgeon's discretion. Retroperitoneal access is achieved through the first trocar incision 15 mm long and 10 mm from the lower border of the tip of the 12th rib (Fig. 102.2). Our preferred method to achieve access to the retroperitoneal space is that Gerota fascia is approached by a muscle-splitting blunt dissection then opened under direct vision. A working space is created by gas insufflation dissection, and the first trocar fixed with a purse-string suture applied around the deep fascia to ensure an airtight seal. Another approach to create the retroperitoneal space is a modification of Gaur balloon technique to dissect the retroperitoneum. Two index fingers of a powder-free surgical glove are placed one inside the other and ligated onto the 5/10-mm trocar sheath. The dissection is then performed by instilling 500 mL of warm saline through the insufflation channel of the trocar. After completed dissection, the trocar is reinserted without the balloon and pneumoretroperitoneum is established (maximum pressure 12 mm Hg or age dependent). A 5- or 10-mm 0-degree telescope is inserted through the first trocar. A second 3-mm trocar is inserted posteriorly near the costovertebral angle, whereas the third 3-mm trocar is inserted 10 mm above the top of the iliac crest at the anterior axillary line. To avoid transperitoneal insertion of this trocar, the working space is fully developed and the deep surface of the anterior wall muscles identified before the trocar is inserted. The insufflation pressure is <12 mm Hg and the flow rate of CO_2 is progressively increased from 1 to 5 L/min.

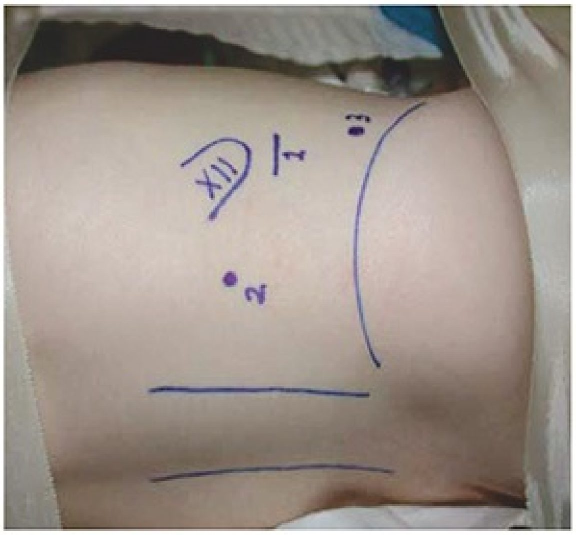

FIGURE 102.2 Port placement for retroperitoneal approach.

The kidney is approached posteriorly, Gerota fascia is incised parallel to the psoas muscle, and the perirenal fat is dissected to reveal the lower pole of the kidney in which the renal pelvis is first identified and then mobilized. The UPJ is identified and minimally dissected to free the UPJ from connective tissue and small vessels are divided using bipolar electrocoagulation. The anterior surface of the UPJ is cleared to identify any polar crossing vessels. In order to dissect the UPJ adequately with minimal trauma, stay sutures of 5-0 Prolene are placed at the UPJ for easy manipulation (Fig. 102.3).

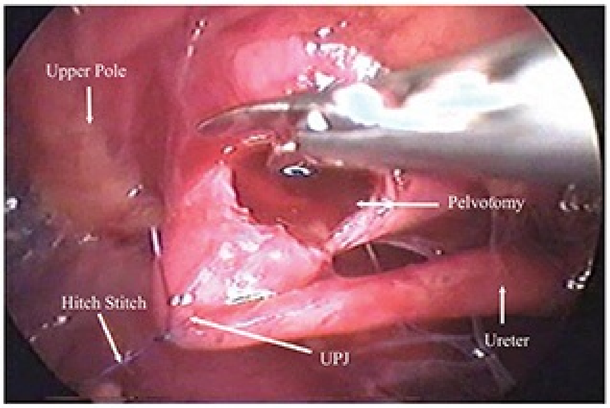

FIGURE 102.3 Retroperitoneal view of 5-0 suture as a hitch stitch at the UPJ.

The traction sutures do not only help to mobilize the UPJ but also facilitate the alignment of the ureter to the trocar axis so that spatulation and suturing is easily accomplished.

Once complete dissection of the UPJ is done, the renal pelvis is partly divided by scissors at the most dependent part, then the ureter is partly divided and spatulated. At all times, the anterior surface of the kidney is left adherent to the peritoneum so that the kidney is retracted medially away from the anastomosis. Nevertheless, if inadvertent dissection of the kidney anteriorly is performed, a fourth trocar (3 mm) is inserted lateral to the lumbosacral muscles near the iliac crest to facilitate medial retraction on the kidney.

The pelviureteric anastomosis begins using 6-0 polydioxanone sutures and a tapered 3/8 circular needle. To facilitate passage of the needles through the 3-mm trocars, needles may be flattened out in the shape of a ski and lubricated. The first suture is placed from the most dependent portion of the pelvis to the most inferior point or vertex of the ureteric spatulation. In the initial few cases, the suture is tied using the intracorporeal technique with the knots placed outside the lumen. In order to facilitate the suturing part of this procedure, two 6-0 undyed polydioxanone 6 cm in length were tied together and one was colored utilizing a surgical marker, thus eliminating a cumbersome step during intracorporeal tying of the crotch stitch. Once the ureter is approximated to the pelvis, the UPJ is maintained on traction and the suture line stabilized. Once half of the anastomosis is accomplished, a 4.7Fr polyurethane ureteral stent is inserted through the suture line to the bladder at the end of the anterior layer reconstruction. Our preferred method for this is through a percutaneous placement of a 12Fr angiocatheter; however, the stent can also be inserted through the costovertebral trocar (Fig. 102.4). To ascertain the position of the stent in the bladder, retrograde filling of the bladder with methylene blue saline is done. The stent remains indwelling for 4 to 6 weeks. Perirenal drainage in the form of a Penrose drain is used. The Foley catheter is left in situ in all patients for 24 hours after surgery. Prophylactic antibiotics (third-generation cephalosporin) are routinely prescribed.

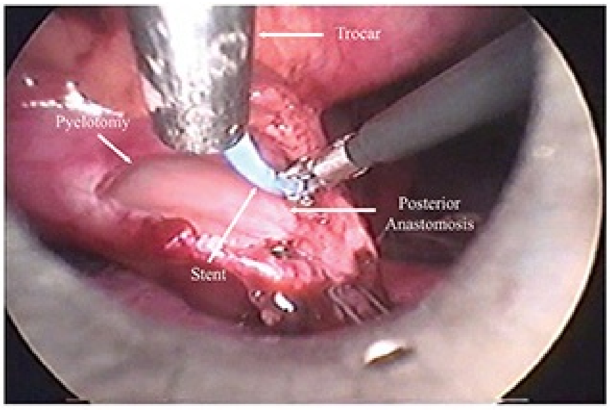

FIGURE 102.4 Retroperitoneal view of the double pigtail ureteral stent inserted through a trocar traversing the ureter antegrade.

Transperitoneal Approach

The first trocar is placed at the umbilicus either through a small open technique or after insufflation with a Veress needle. Utilization of 3- or 5-mm trocars depends on the patient size. Under a year of age, 3-mm trocars are sufficient. However, in any age group, 5-mm trocars with 3-mm instrumentation have been proven the easiest for suture passage in our experience. The abdomen is insufflated with low pressures and high flow to accommodate for suture passage and potential loss of pneumoperitoneum. A 3- or 5-mm 0-degree telescope is inserted through the first trocar. A second trocar is inserted subcostally lateral to the ipsilateral rectus muscle, while the third trocar is inserted 10 mm above the top of the iliac crest lateral to the ipsilateral rectus muscle. A transmesenteric window is performed if the UPJ obstruction is on the left kidney. If the UPJ obstruction is on the right, the colon is mobilized to expose the UPJ (Fig. 102.5).

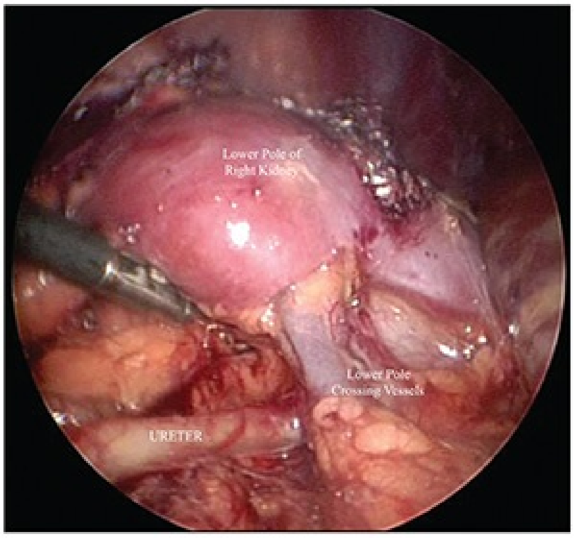

FIGURE 102.5 Transperitoneal view of right lower pole crossing vessels.

The UPJ is identified and mobilized as just described above for the retroperitoneal approach with stay sutures and a hitch stitch. The hitch stitch is placed through the anterior abdominal wall, traversing the renal pelvis, then back through the anterior abdominal wall. It is held in place with a clamp to allow traction control to lift and relax the pelvis as necessary. Once complete dissection of the UPJ is done, the renal pelvis is partly divided by scissors at the most dependent part, then the ureter is partly divided and spatulated.

The anastomosis and percutaneous stent placement is performed as described in the previous section on retroperitoneoscopic pyeloplasty (Fig. 102.6). The stent remains indwelling for 4 weeks. No perirenal drainage is used. The Foley catheter is left in situ in all patients for 24 hours after surgery. Prophylactic antibiotics (third-generation cephalosporin) are routinely prescribed until the catheter is removed. The patients are placed on prophylactic antibiotics until the stent is removed.

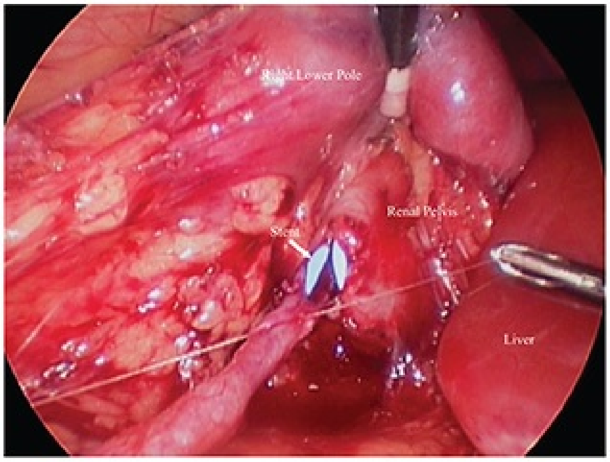

FIGURE 102.6 Completed posterior anastomosis and stent in place. The stent was placed percutaneously after completion of the posterior anastomosis as described.

Special Considerations

Although various reconstructive methods of laparoscopic pyeloplasty such as dismembered or Y-V plasty have been reported, it remains to be determined which methods are most appropriate for which cases of obstruction. For instance, when an aberrant crossing vessel is identified, the polar vessel is dissected and dismembered pyeloplasty is performed to enable the UPJ transposition. After placing the stay suture, the ureter is completely divided and the UPJ and pelvis delivered anterior to the vessels with the help of the stay suture. In some retroperitoneoscopic cases, when we encounter a long segment of obstruction that precludes the creation of a tension-free anastomosis, we perform a transperitoneal laparoscopic approach, and a Y-V plasty can be performed more readily. A concomitant caliceal or renal calculi that cannot be easily accessed via a laparoscopic procedure is not an absolute contraindication if access to the stone is possible, implementing ureteroscopy through one of the access trocars (Fig. 102.7).

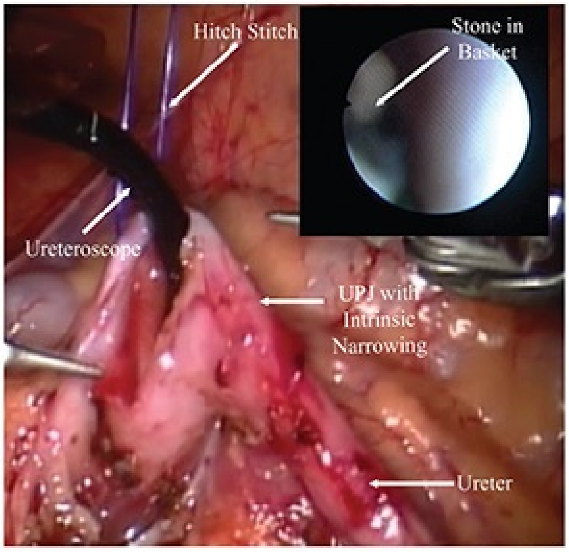

FIGURE 102.7 Concomitant stone extraction. Note the *inset* showing the ureteroscopic view seen during the procedure. The stone is extracted with a basket though an accessory port.

ROBOTIC PYELOPLASTY

Today's surgical robots, or what the true enthusiasts call "surgical actuators," allow 7 degrees of freedom facilitating laparoscopy and broadening the use of minimally invasive surgery. The current industry supported platform, the da Vinci Surgical System (Intuitive Surgical, Sunnyvale, California), provides the advantages of delicate manipulation for reconstructive surgery coalesced with three-dimensional (3D) visualization. It was made for manipulation in hard to reach places. Robotics can overcome many impediments of laparoscopic surgery and decrease the learning curve for minimally invasive surgery, especially for pediatric reconstructive procedures. Robotics also allows the seasoned laparoscopist to become more proficient and refined providing a greater "tool box" to expand minimally invasive surgery to more complex reconstructive procedures (Fig. 102.8). The procedure most performed with the da Vinci system in pediatric urology is pyeloplasty for UPJ obstruction. Complex UPJ surgery has been implemented successfully and safely with the robotic platform. One study showed excellent results of ureterocalicostomy for redo surgery as well as a primary modality for extreme cases of intrarenal collecting systems.

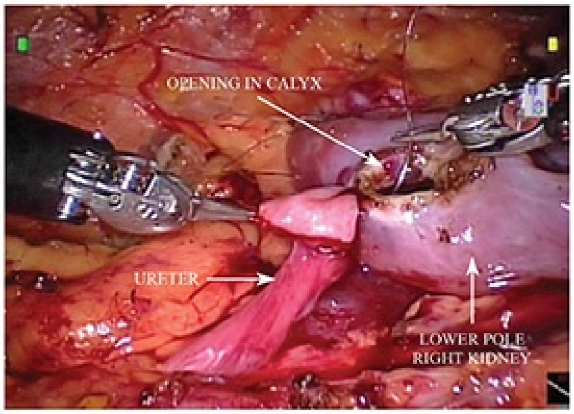

FIGURE 102.8 View of a right robotic ureterocalicostomy.

The techniques and technology have evolved, allowing identical results and utilizing 5-0, 6-0, and 7-0 suture as in open surgeries. The robot has instruments that are available in both 8- and 5-mm sizes. A 5-mm endoscope is available but is monocular and cannot provide the 3D image of the larger scope which makes suturing easier. A fourth arm is available for grasping and retraction. The outcomes for both conventional laparoscopy and robotic-assisted approaches are comparable to the open gold standard. Table 102.1 shows a selected series of pyeloplasty and one series of ureterocalicostomy as examples of this minimally invasive modality even in difficult cases.

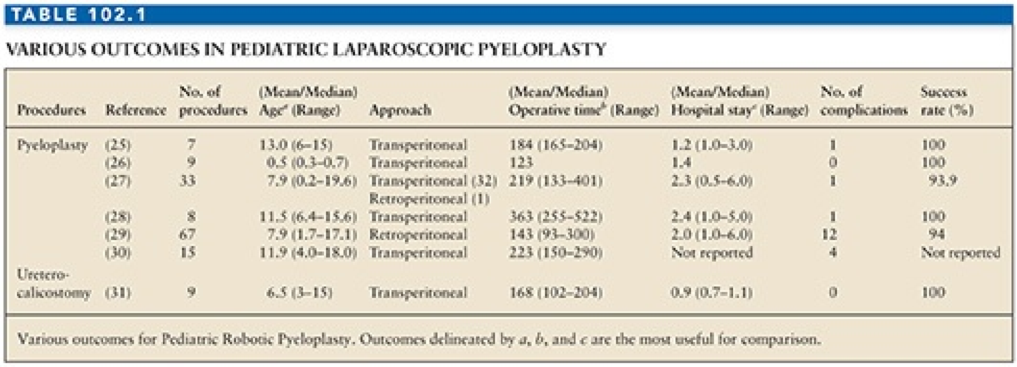

TABLE 102.1

VARIOUS OUTCOMES IN PEDIATRIC LAPAROSCOPIC PYELOPLASTY

Procedures	Reference	No. of procedures	(Mean/Median) Age^a (Range)	Approach	(Mean/Median) Operative time^b (Range)	(Mean/Median) Hospital stay^c (Range)	No. of complications	Success rate (%)
Pyeloplasty	(25)	7	13.0 (6–15)	Transperitoneal	184 (165–204)	1.2 (1.0–3.0)	1	100
	(26)	9	0.5 (0.3–0.7)	Transperitoneal	123	1.4	0	100
	(27)	33	7.9 (0.2–19.6)	Transperitoneal (32) Retroperitoneal (1)	219 (133–401)	2.3 (0.5–6.0)	1	93.9
	(28)	8	11.5 (6.4–15.6)	Transperitoneal	363 (255–522)	2.4 (1.0–5.0)	1	100
	(29)	67	7.9 (1.7–17.1)	Retroperitoneal	143 (93–300)	2.0 (1.0–6.0)	12	94
	(30)	15	11.9 (4.0–18.0)	Transperitoneal	223 (150–290)	Not reported	4	Not reported
Uretero-calicostomy	(31)	9	6.5 (3–15)	Transperitoneal	168 (102–204)	0.9 (0.7–1.1)	0	100

Various outcomes for Pediatric Robotic Pyeloplasty. Outcomes delineated by *a*, *b*, and *c* are the most useful for comparison.

OUTCOMES

The continuing evolution of surgical therapies has had a profound effect on the management of UPJ obstruction. Open and endoscopic interventions are recently being challenged by long-term data that are emerging from laparoscopic pyeloplasty series.

Although controversy still goes on concerning which approach to choose, that is transperitoneal or retroperitoneal, arguments to advocate one approach over another are more theoretical than true evidence-based. We believe that surgeons who have started with laparoscopic nephrectomy using the retroperitoneal approach will be able to naturally extend the indications to retroperitoneal pyeloplasty without changing habits. Nevertheless, the longer time needed for the retroperitoneal approach is probably related to the limited working space, which makes suturing more difficult (20).

It is true that the golden standard of pediatric open renal surgery is the retroperitoneal approach and that minimal invasive surgery should follow the same rules (20). The major advantage of the retroperitoneoscopic approach is that it provides a direct route to the UPJ and thus allows access without interference from intra-abdominal structures. Furthermore, the complication of urine leakage would be better tolerated in the retroperitoneal space than in the intraperitoneal cavity. However, in our experience with the transperitoneal approach with stenting, the rate of urinary leakage from the anastomosis into the abdominal cavity has disappeared.

Laparoscopic pyeloplasty in children has been demonstrated to be feasible and to have satisfactory results (13,15,16,21). Although there are only a few published series on the long-term outcome to date, the short-term data suggest that outcomes are similar to those of open pyeloplasty in children (16,20).

When comparing the gold standard open approach to the laparoscopic approach (20), the mean operative time was significantly shorter in the open surgery group versus the laparoscopy group (96 minutes, range 50 to 150 minutes, vs. 219 minutes, range 140 to 310 minutes, $P < .0001$). On the other hand, the mean postoperative use of analgesics and hospital stay were less in the laparoscopy group. The major disadvantage of the laparoscopic approach is that it is clearly a technically challenging and lengthy surgical procedure because of the high proficiency required for intracorporeal suturing. Although automated devices that facilitate suturing (22) are available, accurate suture placement and unavailability of small size for pediatric application preclude their use (23). Development of novel alternatives to suturing, such as fibrin glue and laser welding may enhance the utilization of the laparoscopic approach; however, the results with these methods alone have not yet matched the success of conventional sutures in providing adequate tensile strength of the anastomosis (24). Thus, for surgeons interested in this approach, suturing experience through practice and training may be the only factor that would help in decreasing the operative times in pediatric series (17). In contrast, suturing using the robotic platform has been greatly facilitated and has significantly mitigated this disadvantage when compared with open pyeloplasty.

Complications

Bleeding—can be seen with access and intracorporeally

Wound infection—postoperative complication

Hernia at the port site and/or internal—postoperative complication. The authors close all trocar sites at the fascial level.

Thermal damage to tissues or organs—Ensure the instruments are always in the visual field.

Trocar or insufflation needle damage to viscera or vessels

Persistent leakage of urine—either from suture line or thermal injury to urinary organ

Stent migration—Ensure stent is completely in the bladder either by postoperative imaging or intraoperative verification with urethral catheter irrigation using methylene blue.

Reobstruction transient and persistent

UTI with stent in place

CONCLUSIONS

Transperitoneal and retroperitoneal approaches are reported to have comparable outcomes. In our experience, the retroperitoneal approach has been difficult in the following scenarios: (a) children under 15 kg with extremely large renal pelvis and (b) previous violation of the retroperitoneal space. For a relatively long obstructed UPJ segment associated with a hydronephrotic extrarenal pelvis, several flap pyeloplasty techniques such as a Culp–Deweerd spiral, Scardino–Prince vertical flap, and a dismembered tubularized renal pelvic wall flap described by Kaouk et al. (24) have been performed.

Reports on the retroperitoneal approach in laparoscopic pyeloplasty are less common despite wide use of this approach in laparoscopic nephrectomy. The level of difficulty of manipulation certainly increases in the retroperitoneal space. We believe that difficulty of manipulation in the retroperitoneal space can be overcome with improvement in operative skill, especially in ambidextrous suturing technique. This approach has some advantages. First, it can avoid dissemination of urine into the peritoneal cavity under retroperitoneoscopic procedures when the renal pelvis is transected. Second, it can minimize the risk of injury to intraperitoneal organs such as the colon and small bowel but with current experiences, this is still not established. Some actually speculate that with the transperitoneal approach, there is less risk to abdominal organs because they are always kept in the field of view.

The success rate of laparoscopic pyeloplasty is equal to that of conventional open pyeloplasty. Transperitoneal and retroperitoneal approaches are reported to have comparable outcomes (16). We believe that laparoscopic dismembered pyeloplasty for UPJ obstruction in infants is technically possible. We also believe the use of an indwelling stent is helpful but not mandatory.

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CHAPTER 103 PEDIATRIC LAPAROSCOPIC NEPHRECTOMY AND PARTIAL NEPHRECTOMY

GLENN M. CANNON, JR. AND RICHARD S. LEE

Since the initial description of a laparoscopic heminephrectomy in a 14-year-old by Jordan and Winslow in 1993 (1), a large amount of literature has been devoted to laparoscopic renal ablative surgery in children. With its decreased length of stay, decreased postoperative opioid requirements, improved cosmesis, and equivalent operative times to open surgery, laparoscopic nephrectomy and partial nephrectomy have become widespread procedures in pediatric urology. In a cost analysis from the United Kingdom, the laparoscopic approach to nephrectomy in children was 54% less expensive than the open approach (2). Currently, robotic systems such as the da Vinci Surgical System (Intuitive Surgical, Sunnyvale, California) are being utilized for more complex reconstructive procedures such as partial nephrectomy. Future research will determine its utility as compared to conventional laparoscopy.

DIAGNOSIS

Children with prenatal or postnatal hydronephrosis and/or febrile urinary tract infection are often imaged with renal ultrasound, voiding cystourethrogram (VCUG), and possibly radionucleotide renal scanning. If there is no evidence of vesicoureteral reflux (VUR), nuclear renography is performed to determine if there is significant obstruction and/or salvageable function. If a clinically significant nonfunctioning renal moiety (e.g., <5% to 10% function by dimercaptosuccinic acid study) is identified, nephrectomy or partial nephrectomy may be considered. Further imaging is usually not warranted, unless there is a history of a continued day and night wetting and possible ureteral ectopia. In these instances, magnetic resonance imaging (MRI) urography may be beneficial (3). In cases of a renal mass, abdominal computed tomography (CT) or MRI is typically obtained to further delineate the mass. In all cases, particular attention should be paid to vascular anatomy, the presence and appearance of the contralateral kidney, the presence and appearance of the ipsilateral and contralateral adrenal glands, and any degree of lymphadenopathy.

INDICATIONS FOR SURGERY

Indications for laparoscopic nephrectomy or partial nephrectomy in children include nonfunctioning kidney, poorly or nonfunctioning upper or lower pole moieties associated with duplicated collecting systems, or renal mass. Typical causes include obstruction, reflux, or ureteral ectopia. Symptoms can possibly include pain, hypertension, infections, or stone formation. Laparoscopy can also be applied when bilateral nephrectomy is required of nonfunctioning kidneys causing hypertension, infections, or nephrotic syndrome prior to renal transplantation. Removal of potentially malignant renal masses has not typically been approached in a laparoscopic fashion in children.

ALTERNATIVE THERAPY

Open nephrectomy or partial nephrectomy is the alternative to a laparoscopic approach. Percutaneous renal ablative procedures such as cryogenic and radiofrequency ablation are not performed in children. An open procedure may be considered if the kidney is large or extensive intra-abdominal adhesions are present. Retroperitoneal laparoscopy can be considered if there is a history of previous abdominal surgery, and transperitoneal laparoscopy can be considered if there is a history of retroperitoneal open surgery.

SURGICAL TECHNIQUE

The following descriptions refer to laparoscopic partial nephrectomy in children. Specific mention is made when the steps of the procedure differ from the performance of a complete nephrectomy. Otherwise, the steps are identical. Although ultimately the surgical approach will be chosen by an individual surgeon’s comfort level and experience, Borzi and Yeung (4) proposed selecting an approach based on the specific type of procedure performed. Reporting an experience of 179 laparoscopic procedures, they recommended a posterior retroperitoneal approach for isolated renal excision without extended ureterectomy, a lateral retroperitoneal approach for complete ureterectomy or access to horseshoe and pelvic kidneys, and a transperitoneal approach when complete moiety excision with lower urinary reconstruction is planned.

Transperitoneal Approach

Preoperatively, patients receive a clear liquid diet for 24 hours and a rectal suppository the night before surgery. Depending on surgeon preference, cystoscopy is performed prior to the start of the partial nephrectomy. A ureteral stent can be placed in the nonfunctioning moiety to assist in identification if necessary. A bladder catheter and orogastric tube are placed.

The affected side is elevated by a 30-degree wedge, and the patient is carefully secured to the operating table. The table is rotated to flatten the patient’s abdomen. With the patient’s abdomen flat, transperitoneal port access is gained using either a Veress needle or with the modified Hasson technique. A camera port (12 mm) is placed at the umbilicus (Fig. 103.1). A second port (5 or 8 mm) is placed superior to the umbilicus in the midline approximately 10 cm from the umbilical port. A third working port (5 or 8 mm) is positioned at the anterior superior iliac spine laterally at a 45-degree offset and 10 cm from the umbilical port. If necessary, a fourth 5-mm port is placed. The fourth port is often helpful in right-sided cases to lift the liver edge and expose the upper pole of the kidney. The table is angled to raise the affected side into a 60-degree flank position. If the da Vinci Surgical System is utilized, the robot is positioned on the ipsilateral side of the patient and angled over the shoulder. The three robotic arms are then engaged to the laparoscopic ports. A 30-degree lens is used in the down position.

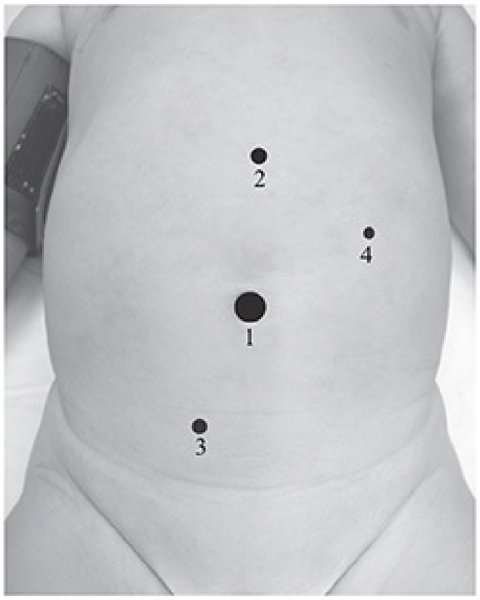

FIGURE 103.1 Port placement for a right-sided laparoscopic partial nephrectomy: camera port (*1*), right handed laparoscopic or robotic port (*2*), left handed laparoscopic or robotic port, if performed laparoscopically, a 10 or 12 mm port could be considered if larger laparoscopic instruments are needed for the procedure (*3*), assistant port (*4*).

The kidney is exposed by medial reflection of the colon. The ureter from the nonfunctioning moiety (or the single ureter for a complete nephrectomy) is identified and mobilized as distally as the iliac vessels. The nonfunctioning ureter is divided. If there is no VUR, the distal end can be left open. If there is VUR, the distal ureter is ligated with an absorbable stitch. The affected pole is manipulated by using the divided proximal ureter as a handle (Figs. 103.2 and 103.3).

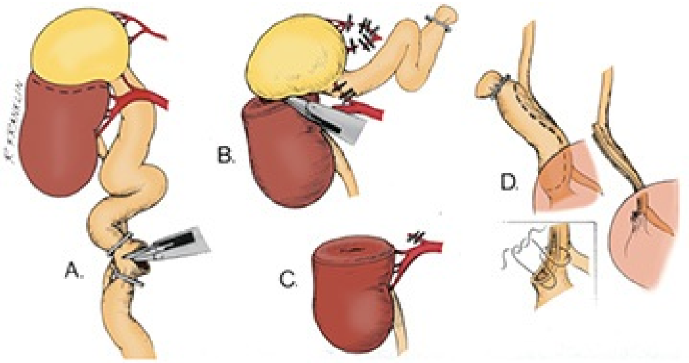

FIGURE 103.2 Laparoendoscopic right upper pole partial nephroureterectomy. **A:** The ureter is clipped and divided in the region of the midureter. **B and C:** The ureter has been dissected from beneath the main renal pedicle and the upper pole vasculature has been clipped. The hydronephrotic cap is dissected off with the parenchyma minimally divided. **D:** The ureter is left attached as the remaining wall of the ureter is dissected and ligated at the bladder wall.

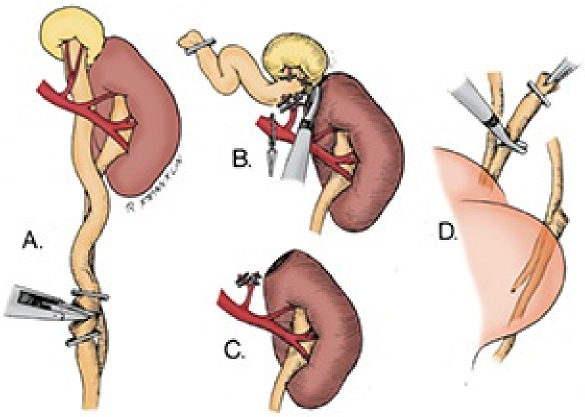

FIGURE 103.3 Laparoendoscopic left upper pole partial nephroureterectomy. **A:** The ureter is clipped and divided in the region of the midureter and dissected in a rostral direction. **B and C:** The upper pole segmental vessels are clipped and the cap of the kidney allowed to demarcate. The plane of amputation is marked, an endoscopic bulldog is applied to the major pedicle, and the upper pole cap is amputated. **D:** The ureter is dissected in a caudal direction to the point of the common vascularity and there amputated with the stump left open.

The proximal nonfunctioning ureter is mobilized and passed posterior to the main renal hilum for an upper pole nephrectomy. During this mobilization, the nonfunctioning ureter is dissected away from the remaining ureter by mobilizing the adventitia of the nonfunctioning ureter toward the remaining ureter. This maneuver is critical to preserve the blood supply of the remaining ureter.

The nonfunctioning ureter is mobilized to the kidney and the Gerota fascia is opened. The ureter is passed posterior to the main renal hilum for an upper pole nephrectomy. Suprahilar, cephalad traction on the ureter should provide access to the upper pole (nonfunctioning) hilum. If the blood supply is not clearly identified, laparoscopic bulldogs may be placed on the presumed upper pole vessels. A clear demarcation between the upper and lower pole should be visible. The upper pole vessels are clipped and divided. The renal pelvis of the nonfunctioning moiety is separated from the normal parenchyma using blunt dissection to better identify the demarcation between the functioning and nonfunctioning moiety. Large hydronephrotic moieties can be opened to help delineate the separation between the upper and lower pole. The nonfunctioning moiety is excised using electrocautery or the harmonic scalpel along the line of vascular demarcation (Fig. 103.4). Any collecting system injuries to the remaining pole should be closed with an absorbable suture. Perirenal fat is used as a bolster prior to closing the cut surface of the remaining moiety with 4-0 absorbable monofilament suture.

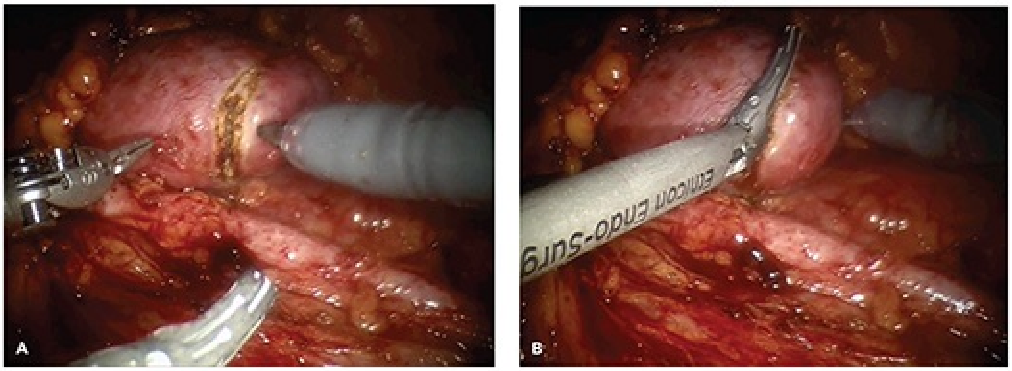

FIGURE 103.4 Transperitoneal view of the left lower pole demarcated by electrocautery prior to removal (A), with subsequent excision by harmonic scalpel (B).

If a complete nephrectomy is to be performed, after the ureter is divided and Gerota fascia opened, the renal vessels are dissected and divided using clips or an endovascular stapler. The kidney is mobilized and removed.

After inspection for hemostasis, a retroperitoneal drain is placed and the specimen is removed through the camera port. If a complete nephrectomy is performed, a drain is typically not placed. Local anesthetic is injected into the port sites. Most patients, if not all, do not require epidural analgesia. The bladder catheter is removed on the first or second postoperative day, depending on whether further bladder work is required. The drain is removed when there is minimal drainage. The patient is discharged when comfortable with diet and oral analgesics.

Retroperitoneal Approach

Retroperitoneal access to the kidney can be obtained by either a prone or a flank approach. The posterior prone retroperitoneal approach has been recommended for children with end-stage renal disease who may require immediate peritoneal dialysis (5). In the prone approach, initial retroperitoneal access is gained at the costovertebral angle using an open technique. Balloon inflation to 15 to 20 mm Hg of pressure is utilized to dissect and create the retroperitoneal space. Working ports are placed under direct vision inferior to the camera port and just above the iliac crest (Fig. 103.5). In this position, the kidney will move anterior by gravity, thereby exposing the hilar vessels. The psoas muscle is identified as a landmark. During nephrectomy, exposure and dissection of the hilum are performed first with subsequent identification and division of the ureter. In partial nephrectomy, minimal mobilization of the remaining vessels and moiety should be performed to prevent vasospasm of the remaining moiety. The affected vessels should be divided and the nonfunctioning moiety removed as in the transperitoneal approach. The ureter is used as a handle to manipulate and isolate the affected moiety. Collecting system injuries should be closed appropriately, and the edges of the remaining moiety may be sutured together for further hemostasis. A retroperitoneal drain is typically left in place.

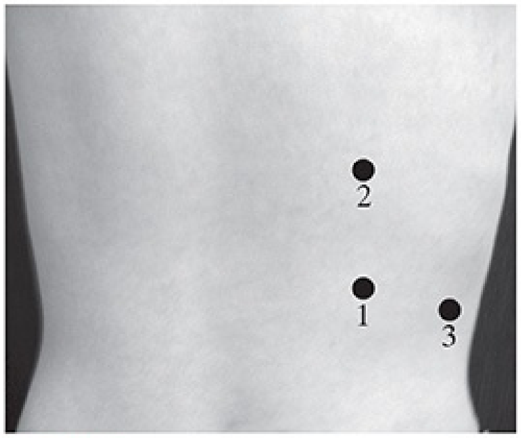

FIGURE 103.5 Port placement for right-sided prone retroperitoneal laparoscopic renal surgery: camera port (*1*), laparoscopic or robotic ports (*2*) and (*3*).

The flank approach is similar except that the working space is developed with the camera port just below the tip of the 12th rib. The working ports are placed along a transverse line with the camera medially and laterally after dissection of the peritoneum from the anterior abdominal wall. The remainder of the procedure is identical to that of the prone approach.

OUTCOMES

Janetschek et al. (6) presented the first series of pediatric laparoscopic heminephrectomy. In 12 cases, 7 upper renal poles were removed for ectopic refluxing megaureter and obstructive ureteroceles. Five lower poles were removed for reflux nephropathy. Their blood loss was minimal (10 to 30 mL), there were no complications, and mean operative time was 222 minutes. Horowitz et al. (7) later reported a series of 14 laparoscopic upper pole heminephrectomies with a mean operative time of 100 minutes.

To assess for potential benefits of laparoscopic renal ablative surgery over open procedures, Robinson et al. (8) retrospectively compared 22 consecutive partial nephrectomies of which 11 were performed laparoscopically and 11 performed open in a nonrandomized fashion. Although the mean operative time was significantly longer for the laparoscopic group (200 minutes versus 114 minutes), there was no difference in mean hospital stay. Patients in the laparoscopic group had a significantly lower opioid requirement than the open group. Piaggio et al. (9) compared intraperitoneal laparoscopic partial nephrectomy to an open retroperitoneal approach. They noted that length of hospitalization was shorter in the laparoscopic group and stated that the procedure is feasible even in infants under 6 months of age.

Success in laparoscopic partial nephrectomy has also been reported via a retroperitoneal approach. Castellan et al. (10) also reported their experience utilizing both transperitoneal and retroperitoneal heminephrectomy. Their overall complication rate was 10%, which included urine leak, pneumothorax, urinary tract infection, and hypertension. Lee et al. (11) performed an age-matched comparison of pediatric patients undergoing retroperitoneal laparoscopic partial nephrectomy to open surgery. Compared to open partial nephrectomy, the laparoscopic approach was eventually associated with equivalent operative times, significantly shorter length of stay, and less postoperative opioid requirements.

With the advent of robotic-assisted laparoscopic surgery (RALS), robotic-assisted laparoscopic partial nephrectomy (RALPN) has been performed and has demonstrated similar outcomes to open and standard laparoscopic surgical techniques (12,13).

COMPLICATIONS

The most severe complication that can occur during laparoscopic nephrectomy and partial nephrectomy is a major vascular injury. This is most likely to occur during trocar insertion or during the hilar dissection. Trocar injuries may be prevented by using an open Hasson approach. Meticulous attention must be paid during the hilar dissection. The vascular anatomy needs to be clearly defined prior to division of the renal vessels. When endovascular staplers are utilized, the surgeon must confirm that only the renal vessels are included within the stapler.

Other complications can include bowel injury, bleeding, infection, or urine leak resulting in urinoma formation. Bowel injuries can occur with inadvertent trocar placement or during dissection secondary to instrument handling or electrocautery misuse. Urine leaks are often discovered by elevated postoperative drain output. They are often managed with bladder decompression, with or without ureteral stent placement. Asymptomatic postoperative retroperitoneal fluid collections can be observed. Symptomatic retroperitoneal fluid collections may require percutaneous drainage and assessment for creatinine. A late complication that can occur is loss of function in the ipsilateral remaining moiety, eventually resulting in hypertension or, worse, loss of the moiety. If severe, this may require completion of a nephrectomy. This complication may be prevented with meticulous dissection and minimal mobilization of the hilum and kidney of the functioning moiety to prevent any intimal vascular injury or vasospasm.

As experience with laparoscopic nephrectomy and heminephroureterectomy increases, operative time and estimated blood loss can improve. Yucel et al. (14) retrospectively reviewed their experience with laparoscopic ablative renal surgery performed by one surgeon over a 6-year period. In the fourth year of their experience, they noted a statistically significant improvement in operative time for laparoscopic nephrectomy and in estimated blood loss for laparoscopic heminephroureterectomy. They concluded that their experience should continue to encourage pediatric urologists to perform laparoscopic renal surgery.

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CHAPTER 104 UROGENITAL SINUS AND CLOACAL ANOMALIES

RICHARD C. RINK, JEFFREY A. LESLIE AND MARTIN KAEFER

Anomalies of the urogenital sinus occur on a spectrum ranging from a mild distal communication between the urethra and vagina to a very complex confluence between the urethra, vagina, and rectum. For this last-mentioned complex group, a distal common channel for all of these structures drains to a single perineal opening (Fig. 104.1A). The clinical presentation of this single opening results from persistence of the cloaca and is essentially a severe urogenital sinus abnormality with a high imperforate anus (Fig. 104.1B). In addition to a more bizarre and diverse internal anatomy, patients with cloacal anomalies have a high incidence of other serious midline congenital anomalies. Important elements of baseline evaluation and surgical management of urogenital sinus and cloacal anomalies are discussed in detail in this chapter.

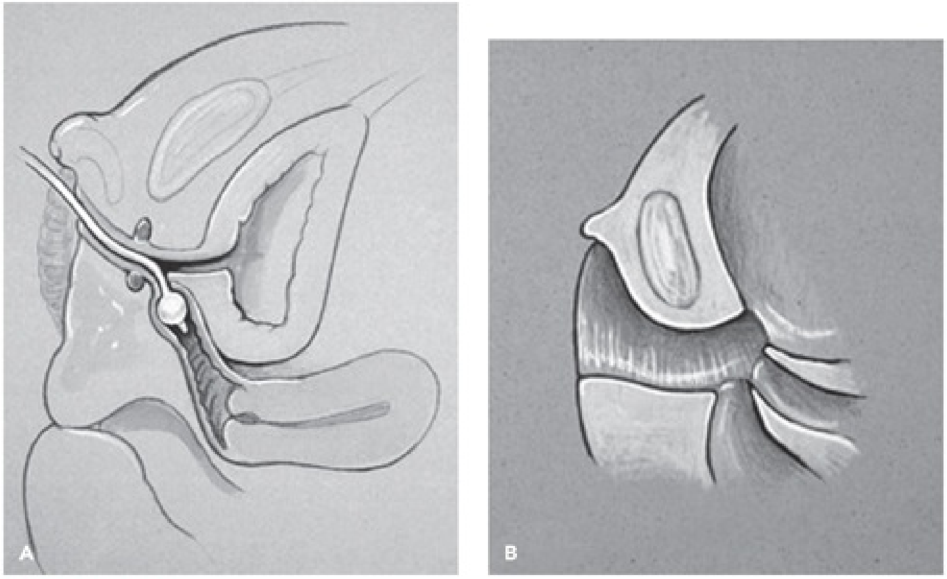

FIGURE 104.1 A: Urogenital sinus. The confluence of the vagina with the urethra is near the bladder neck and thus "high." A Fogarty catheter is in the vagina. B: Cloacal anomaly with the urethra, vagina, and rectum all exiting a single perineal opening. (From Indiana University School of Medicine, Office of Visual Media, with permission.)

Urogenital sinus abnormalities (no rectal involvement) in general occur in one of two forms: pure urogenital sinus anomalies and females with disorders of sexual development (DSD) conditions. The latter group is much more common. In these children, surgical management must address not only the urinary and vaginal communication but also the virilization of the clitoris and labia.

DIAGNOSIS

The majority of children with urogenital sinus abnormalities are detected at birth due to genital ambiguity. The initial evaluation in this group of children requires a team approach to rapidly identify the etiology and requires rapid chromosomal and endocrinologic studies. The history and physical examination are often helpful in establishing a correct diagnosis. Congenital adrenal hyperplasia (CAH) secondary to 21-hydroxylase deficiency is by far the most common etiology. Some children may be identified antenatally on ultrasound by noting a fluid-filled mass (distended vagina) posterior to the bladder and indeterminant genitalia. Persistence of the cloaca is suspected in utero when large fluid-filled pelvic structures are noted associated with bilateral hydroureteronephrosis, oligohydramnios, and ascites. A 46XX karyotype is found. Hydrocolpos due to retention of urine and secretions results in upper tract distention, and ascites occurs due to retrograde flow through the genital tract into the peritoneum. The rectum and bladder may also be filled with urine, giving rise to the other fluid-filled structures.

Prematurity and multiple congenital defects are common in children with cloacal anomalies. Initial evaluation of these children should therefore include medical stabilization and evaluation for midline abnormalities. Abdominal distention is common and may result in respiratory embarrassment. Cardiac, renal, and upper gastrointestinal anomalies and spinal dysraphism are frequently identified. Although these infants are uniformly female, ambiguity of the genitalia may occur and should be investigated. A single perineal opening is noted anteriorly, and the anus is absent. The perineum is in general flat with variable amounts of labial tissue mounded around the anterior orifice. Occasionally, a prominent phallic structure is found. The buttocks are often poorly developed, and the sacrum may be deficient on abdominal plain film.

Renal ultrasound reveals anomalies of number and fusion. Magnetic resonance imaging (MRI) clarifies the complex pelvic relationships, evaluates the structural quality of the sphincter complex, and defines the anatomy of the lumbosacral spine and distal spinal cord. A gender assignment committee is convened for all children with genital ambiguity. This committee includes an endocrinologist, geneticist, pediatric urologist, neonatologist, psychiatrist/psychologist, and the family. The child must be stabilized. Genitography to help determine the anatomy (i.e., length of common sinus, location of vaginal confluence, status of bladder, presence or absence of vesicoureteral reflux, or vaginal duplication) has routinely been used in urogenital sinus and cloacal anomalies. We have recently shown that the anatomy is delineated correctly in only 72% of CAH patients (1). Patients with cloacal anomalies have a communication between the urogenital tract and rectum, and vesicoureteral reflux is commonly identified. Endoscopy is imperative to understand this complex anatomy. Ultrasonography of the pelvis and kidneys is also of help to identify the uterus, ovaries, and any vaginal distention, or, in the case of cloacal anomalies, it may reveal hydronephrosis or increased echogenicity suggestive of renal dysplasia. The adrenal glands in CAH may be prominent with a cerebriform appearance (2). MRI of the pelvis is an excellent tool to determine pelvic anatomy and note the presence of lumbosacral spinal cord anomalies that may be present.

Pure urogenital sinus anomalies are in general not detected early because of normal external genitalia. These patients are usually found at puberty with hydrometrocolpos or difficulty with tampon insertion. Some children are identified earlier with incontinence and urinary tract infection (UTI) from urine pooling within the vagina. Those with pure urogenital sinus anomalies are also more likely to have other organ system abnormalities than those with a urogenital sinus associated with DSD.

INDICATIONS FOR SURGERY

It is very important for the reader to understand that there are many controversies associated with the care of children with genital ambiguity. The controversies primarily involve the role of surgical management including timing, types of repairs, outcomes—particularly sensory loss, and lack of patient consent. Ideal surgical timing for those with DSD is yet to be defined (3). Surgery for DSD generally involves clitoroplasty, labioplasty, and vaginoplasty. The timing of the surgery is the most controversial with proponents falling into one of four groups: (a) all components done in infancy, (b) clitoroplasty and labioplasty in infancy with delayed pubertal vaginoplasty, (c) all components done at puberty, and (d) no surgery unless the patient is of age to request it. There are advantages and disadvantages to each of these options. For CAH and cloacal anomalies, surgery is most often performed in infancy. We believe strongly that no family should be talked into surgery but should rather be given all advantages and disadvantages of the various options and support in their decision-making process. Creighton et al. (3) have noted that the idea of “doing nothing” can be a stressful concept for the parents. Clearly, gender assignment when the individual’s ultimate gender identity is unknown is a challenge and is at the core of this controversy (4). The family should also be given access to support groups such as the CARES Foundation, Accord Alliance, and MAGIC Foundation to aid in this complex decision.

For the purposes of this presentation, we will assume that the family and the gender assignment team agree to proceed with surgery. Although the majority in the United States elect surgery as an infant, it is imperative for the family to know that this “single stage surgery” may require secondary vaginal surgery at puberty most commonly due to introital or vaginal stenosis. This is usually a minor procedure. Even among proponents of early clitoroplasty, labioplasty, and vaginoplasty, it is understood that in the child with a very high, very small vagina, it may be more appropriate to postpone vaginoplasty until puberty. All techniques described herein are applicable to the infant or pubertal child. We are in agreement with others that these procedures are technically more challenging after the onset of puberty (5).

DECOMPRESSION THERAPY

While most of those with a urogenital sinus undergo reconstruction in the first few months, the complex nature of cloacal anomalies and their high incidence of other congenital defects may necessitate a delay in formal reconstruction while the child is stabilized. Certainly, temporary diversion of the gastrointestinal tract by colostomy is essential, and decompression of the urinary tract may be required. This may be done by clean intermittent catheterization, but if this is not adequate, a temporary cutaneous vesicostomy or vaginostomy may be needed. There has been concern historically that vaginostomy may tether the vagina to the abdominal wall making later vaginoplasty more difficult. However, this has more recently been challenged by Levitt and Pena (6,7), and vaginostomy has been valuable in some patients in our hands. In the current era of Malone antegrade continence enema (MACE appendicocecostomy) procedures to achieve fecal continence, nearly all will ultimately undergo complete reconstruction, including a rectal pull-through.

SURGICAL TECHNIQUE

All children with a very high vaginal confluence or a cloacal anomaly receive a polyethylene glycol electrolyte solution bowel preparation and prophylactic parenteral antibiotics preoperatively. Those with a low to midlevel confluence and most CAH patients receive only a preoperative enema and broad-spectrum antibiotics. CAH children must receive “stress dose” steroids prior to surgery.

Endoscopy is performed with the child in the lithotomy position. This is one of the most important steps in reconstruction, as it defines the level of vaginal confluence and allows identification of any other lower genitourinary pathology, such as vaginal duplication, ectopic ureter, and so forth. We believe that the distance of the vagina from the bladder neck is the most critical aspect and dictates the type of vaginoplasty. Endoscopy also allows placement of a Fogarty catheter into the vagina, which is left indwelling with the balloon inflated. Correct placement is confirmed by repeating endoscopy. The Fogarty balloon will aid in identification of the vagina during the reconstruction. A separate small Foley catheter is passed into the bladder.

Historically, urogenital sinus surgery has been performed with the child in the lithotomy position. While this position is acceptable, we have found it much easier to prepare the entire lower portion of the body circumferentially to allow access to the abdomen and perineum and to allow the child to be supine or prone (Fig. 104.2A and B). The supine portion of the procedure is done with the child "frog-legged," with the buttocks elevated on towels. This position dramatically improves visualization for the surgical assistants and does not hinder the surgeon. By far the most common group of patients with a urogenital sinus anomaly to require surgical reconstruction is the group with CAH, who have not only a urogenital sinus but also virilization of their external genitalia. This includes clitoral hypertrophy, absence of the labia minora, and anteriorly placed labia majora. Therefore, most patients will undergo clitoroplasty, labioplasty, and vaginoplasty.

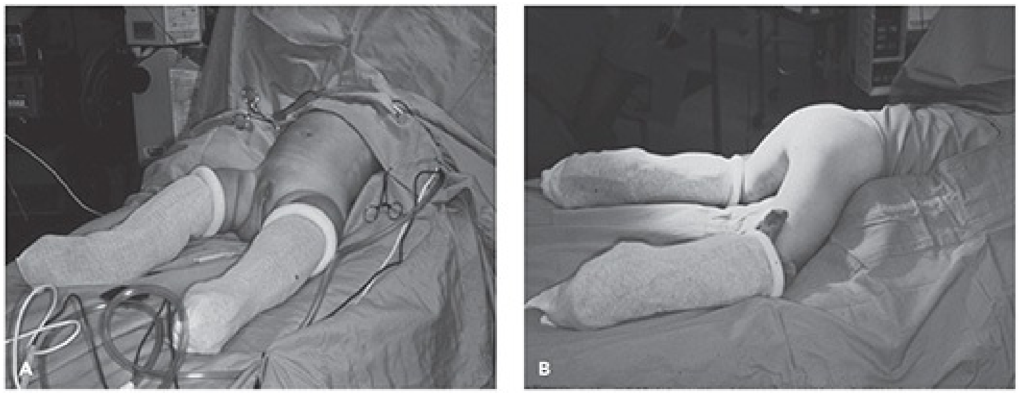

FIGURE 104.2 Total lower body preparation. A: Supine position allows access to perineum and abdomen. B: Child has been rotated prone, allowing access for a posterior sagittal approach.

Clitoroplasty

In cases of genital ambiguity, the operation begins with placement of a traction suture in the glans clitoris. Using a skin scribe, the proposed incisions are outlined as shown in Fig. 104.3. Historically, a very wide-based inverted U-shaped perineal flap has been created. Improved cosmesis occurs, however, if the flap has a narrower base similar to an omega (8), avoiding the appearance of a triangular introitus. After injecting 0.5% lidocaine with 1:200,000 epinephrine subcutaneously along the proposed suture lines, the clitoroplasty is begun. The initial incision is carried out dorsally at the junction of the inner preputial surface with the outer clitoral skin. This preserves the inner preputial skin for a clitoral hood and maximizes sexual sensitivity. The entire clitoris is degloved by creating a plane between the Buck fascia and the dartos circumferentially. Ventrally, the incision is carried around the urogenital sinus meatus. The rounded apex of the perineal flap should extend to near the meatus. In situations where the urogenital sinus meatus is at the base of the clitoris, parallel incisions on either side of the urogenital sinus plate will allow its preservation for later use in the reconstruction.

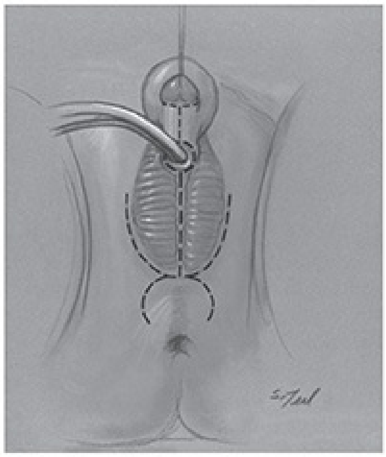

FIGURE 104.3 Proposed initial incisions. Notice the omega-shaped perineal flap. The meatus is encircled. (From Indiana University School of Medicine, Office of Visual Media, with permission.)

The perineal flap is elevated with its underlying subcutaneous and adipose tissue to expose the urogenital sinus. Dorsally, the suspensory ligament is divided and the bifurcation of the corporal bodies is exposed ventrally. With the entire clitoris now exposed, a tourniquet is placed at its base. A vertical ventral midline incision is made along the entire length of each corporal body to the glans (9) (Fig. 104.4A). The erectile tissue is exposed and excised, with care taken not to injure the Buck fascia, the tunica albuginea, the neurovascular bundle, or glans. This is performed bilaterally from the glans to the level of the bifurcation (Fig. 104.4B). The proximal end of each corporal body is oversewn with 5-0 polyglycolic acid sutures to prevent bleeding. With the Buck fascia folded, the glans is now secured to the corporal stumps with 5-0 polydioxanone sutures. We had previously sutured the glans to the pubis but found that this technique prevents appropriate concealment of the glans. At times, the glans is quite large, but one should resist aggressive glans reduction. If any reduction is done, it should only occur on the ventral aspect of the glans to prevent loss of sensation (10).

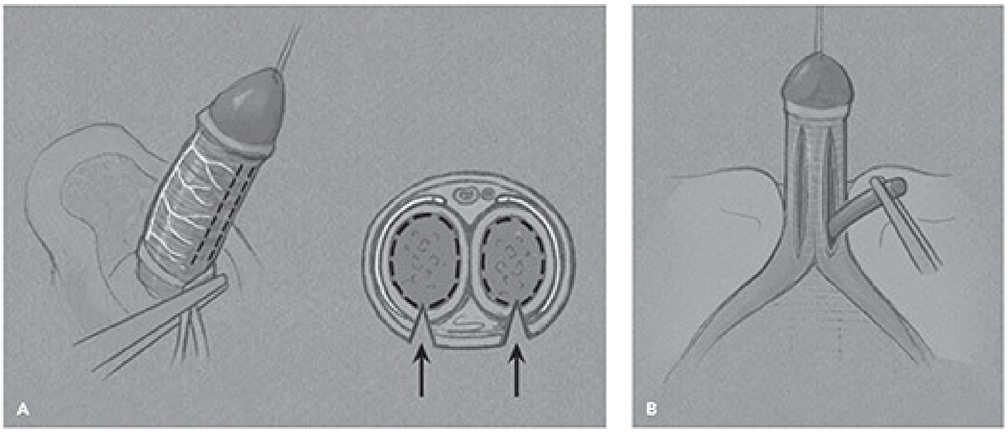

FIGURE 104.4 Clitoroplasty. **A:** The longitudinal incisions must be ventrally placed to avoid injury to the neurovascular supply. **B:** The erectile tissue is removed. There is no excision of any of the tunic, and the neurovascular pedicles are never manipulated. (From Indiana University School of Medicine, Office of Visual Media, with permission.)

Vaginoplasty

The most complex component of reconstruction of the urogenital sinus is the vaginoplasty. While multiple techniques of vaginal reconstruction have been described, they all fall in general into four types: (a) cut-back vaginoplasty, (b) flap vaginoplasty, (c) pull-through vaginoplasty, and (d) vaginal replacement. The type of vaginoplasty is determined by the location of the confluence between the vagina and the common urogenital sinus.

The *cut-back vaginoplasty* is applicable only for minor labial fusion and we believe is contraindicated for any true urogenital sinus anomaly. In this procedure, the sinus is opened with a midline vertical incision that is then closed transversely in a Heineke-Mikulicz fashion. Although we believe there is a high risk of inadequate opening of the narrow distal vagina with the cutback technique and therefore of historical significance only, some have recently reported it to be useful in low confluence (<1 cm) Prader I and II patients (11).

Low Vaginal Confluence

For the low confluence, a *flap vaginoplasty* is performed. This procedure leaves the vagina in the same anatomic location but opens the sinus to provide a larger common opening for the urethra and vagina (9). It is contraindicated in patients with a high vaginal confluence. The previously elevated perineal flap must be long enough to allow a tension-free anastomosis to the normal-caliber proximal vagina. Redundancy of the flap, however, will create a lip of tissue at the introitus. The exposed ventral aspect of the sinus is opened in the midline, and the incision is carried through the narrowed distal one-third of the vagina into the normal-caliber proximal vagina. It is very important to open into the normal-caliber vagina to prevent later vaginal stenosis. It is also noteworthy that the flap vaginoplasty does not change the vaginal location or confluence but merely exposes the vagina by widely opening the introitus (9). Because the anterior and lateral aspects of the vagina are untouched, stenosis is less common. This is overwhelmingly the most common procedure for urogenital sinus anomalies and has the least risks but does have the drawbacks of the posterior wall of the vagina being skin and often results in a hypospadic urethra.

High Vaginal Confluence

If the vaginal confluence is near the bladder neck, a flap vaginoplasty is contraindicated, as it will result in severe female hypospadias with urine pooling. Deep spatulation of the sinus and posterior vagina may permanently open and injure the sphincteric mechanism. Therefore, a *pull-through vaginoplasty*, which allows a complete separation of the vagina from the sinus, has been recommended (12). The sinus is closed in layers to create a urethra, and the vagina is brought to the perineum. In this technically demanding procedure, the vagina is completely separated from the sinus. The dissection of the anterior wall of the vagina from the urethra and bladder neck is the most difficult part of the procedure, and if not done with care and excellent exposure, it may result in injury to the urethra or sphincteric mechanism. The initial portion of this procedure is identical to the flap vaginoplasty. It is important to expose the entire posterior wall of the vagina by dividing the bulbospongiosus muscle and sweeping the rectum posteriorly. The sinus is opened in the midline until the Fogarty balloon is exposed in the vagina. At this time, we have found it most helpful to rotate the patient to the prone position and elevate the posterior wall of the vagina with a malleable retractor, providing excellent exposure of the anterior wall of the vagina and its confluence with the urethra (13). Stay sutures on the vagina are very helpful. With the vagina separated from the urethra and sinus, the opened sinus is closed in layers over a catheter, allowing the sinus to become the urethra. Unfortunately, “pull-through” is at times a misnomer: Even following complete circumferential vaginal mobilization, the vagina may not reach the perineum. In these situations, the perineal flap will create the distal posterior vaginal wall and the anterior wall has historically been created by preputial or labial flaps. Passerini-Glazel (14) has also incorporated the mobilized sinus with the clitoral skin to create the anterior wall. This later procedure remains popular today. In the very high vagina where exposure is often limited, it may be helpful to split the anterior wall of the rectum as described by Dòmini et al. (15) (ASTRA technique). In extreme situations, bowel interposition may be required to create the distal vagina. A Penrose drain is left in the vagina, and the Foley remains in the urethra.

Labioplasty

Having completed the clitoroplasty and vaginoplasty, only the labial reconstruction remains. The phallic skin is unfurled and divided in the midline longitudinally (similar to Byars flaps), stopping short of the base to allow creation of a clitoral hood (Fig. 104.5A). We secure the split clitoral skin to the preserved preputial skin to create a clitoral hood. It is helpful cosmetically to plicate the clitoral skin in the midline prior to its anastomoses to the inner surface of prepuce (16). These skin flaps are now sutured in place inferiorly along either side of the vagina to create labia minora. The anteriorly displaced labia majora are mobilized posteriorly by making lateral incisions in a Y-V fashion (Fig. 104.5B). The mobilized labia majora are now sutured to the labia minora and to the apex of the perineal flap. This step moves the labia posteriorly to their normal location on either side of the vagina (9).

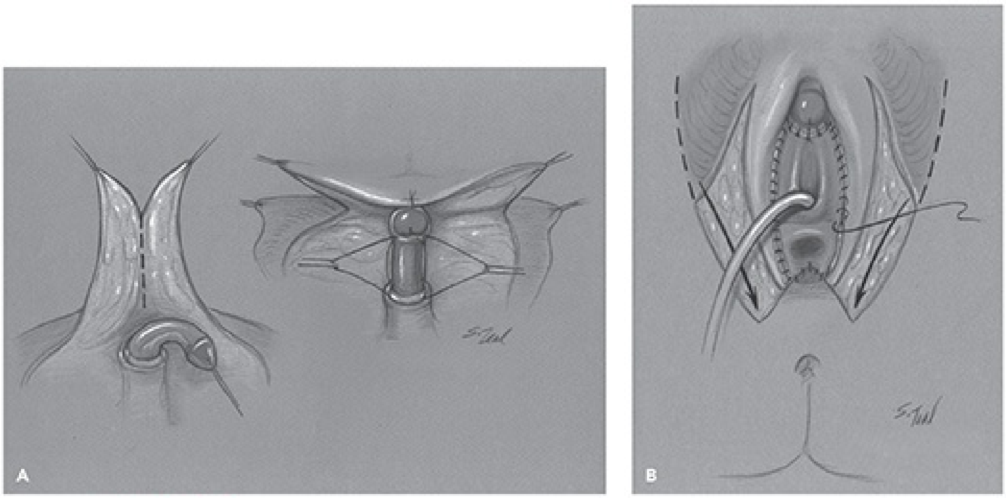

FIGURE 104.5 **A:** The phallic skin is divided in the midline and used to create labia minora. The incision should stop well short of the base to allow creation of a clitoral hood. **B:** Y-V plasty of the labia majora moves the labia inferiorly to place the urethra and vagina between the labia in a more normal location. (From Indiana University School of Medicine, Office of Visual Media, with permission.)

Cloacal Anomalies

Surgical management of children with cloacal anomalies occurs in several important steps, but the formal reconstruction is best performed in a single stage. The rectal pull-through should never be done in isolation without the vaginoplasty. Neonates require early diverting colostomy. Hendren (17) prefers a divided transverse colostomy to leave adequate distal colonic length and leaves the left colic blood supply intact for subsequent rectal pull-through. A long distal colonic segment, however, can allow persistent retention of urine in the mucus fistula and result in refractory hyperchloremic metabolic acidosis. A divided colostomy in the descending colon just after the colon takes off from its retroperitoneal attachment is now recommended by Levitt and Peña (6). Preliminary mapping of the anorectal sphincter complex provides prognostic information for future rectal pull-through.

Decompression of the genitourinary tract is performed during endoscopic investigation of the cloacal anatomy. Inspissated mucus and meconium debris are drained. Because the bladder neck and vagina are often closely related, the vagina passively retains voided urine. If vaginal voiding is a problem, intermittent catheterization of the common channel will allow decompression, with the catheter most likely entering the vagina rather than the bladder. Poor emptying is suspected in children with persistence of hydronephrosis postnatally. Alternatively, if the common channel is narrow and more urethral-like, it can be opened distally to facilitate voiding. If the previously described measures fail, cutaneous vesicostomy or cutaneous vaginostomy will allow free drainage.

Severe anomalies of other organ systems should be corrected early. Other urinary tract abnormalities that may compromise long-term renal function should be addressed. Colonization of the urinary tract is common, but symptomatic infections mandate aggressive therapy. Assuming that all other congenital issues have been satisfactorily addressed, formal repair of the cloaca with the Peña posterior sagittal anorectovaginourethroplasty (PSARVUP) is planned for 6 to 12 months of age (18). This demanding procedure should be completed in a single stage, capitalizing on the virgin tissue planes for both anorectal and urogenital reconstruction.

The initial preparations for repair of the persistent cloaca are similar to those described above for the high-confluence urogenital sinus. After a circumferential lower body preparation and endoscopic placement of Fogarty catheters in the vagina(s) and rectum and a Foley catheter in the bladder, the patient is placed prone on the chest and pelvic rolls. The sphincter complex is stimulated, and the optimal positions for the anus, perineal body, vagina, and urethra are marked. The perineum is incised in the midline from the tip of the coccyx to the posterior margin of the single perineal orifice. The sphincteric muscles are split in the midline and tagged to facilitate subsequent reconstruction. The rectal communication is sharply dissected off the common channel, and the distal colon is mobilized for pull-through. Occasionally, abdominal exploration is required to achieve adequate rectal mobilization. At this time, the entire urogenital system is circumferentially mobilized toward the perineum by the Peña technique of *total urogenital mobilization* (19). Even if this maneuver cannot bring the vagina to the perineum, it does improve exposure to the confluence for completion of a pull-through vaginoplasty. Duplicate vaginas are often encountered and are combined by division of the vertical septum. Vaginal agenesis or atresia requires bowel interposition for vaginoplasty, and again, this is best performed at the time of rectal pull-through and urethroplasty.

Total and Partial Urogenital Mobilization

Total urogenital mobilization (TUM), described by Peña in 1997 (19), entails complete circumferential dissection of the intact urogenital sinus, urethra, and vagina from the pubis (Fig. 104.6A). This was originally proposed for cloacal anomalies but has since been often applied to those with a urogenital sinus only. TUM allows the midlevel vagina to be moved to the perineum easily, thus avoiding a *pull-through* vaginoplasty, and while the high-confluence vagina may still require a *pull-through* vaginoplasty, the separation of the vagina from the urinary tract is much more easily performed.

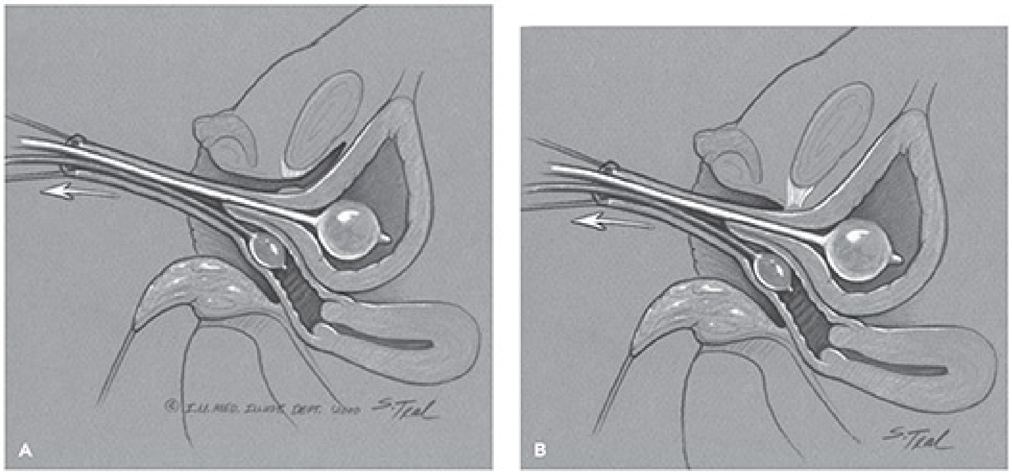

FIGURE 104.6 **A:** Total urogenital mobilization. Complete circumferential mobilization of the intact sinus with the dissection well above the pubis. **B:** Partial urogenital mobilization. The anterior dissection ceases at the pubourethral ligament. *Arrows* indicate direction of tissue mobilization. (From Indiana University School of Medicine, Office of Visual Media, with permission.)

The initial incisions are similar to those described previously, but the urogenital sinus is mobilized intact off the corporal bodies and is carried out between their bifurcation to the pubourethral ligament. At this time, the dissection is continued posteriorly in the midline, separating the rectum from the posterior wall of the vagina. The Fogarty balloon within the vagina is palpated, and an incision is made into the vaginal wall posteriorly near the confluence. If the vagina reaches the perineum, no further dissection is performed and instead partial urogenital mobilization is used (20). In Peña's original description, the mobilized sinus was amputated, but Rink et al. (21) have shown that this is important tissue to save for the reconstruction. If the vagina does not reach the perineum, then the sinus is mobilized between the corporal bifurcation and off the pubis (TUM). When these avascular attachments from the pubis are divided, the sinus moves toward the perineum. If the sinus is near the perineum, we still believe a flap vaginoplasty should be performed to prevent vaginal stenosis. The redundant sinus is then split ventrally to create a mucosa-lined vestibule (Fig. 104.7A and B) (21,22). Recently, we described splitting the sinus laterally to create a posterior vaginal wall (Fig. 104.8) (23). This is also a form of *flap vaginoplasty*, but the posterior flap is native urogenital tissue rather than perineal skin. If the vagina is high following the TUM, then the vagina is separated from the sinus as described previously for a pull-through vaginoplasty. This vaginal separation is again more easily achieved by placing the patient prone over chest rolls. The mobilized sinus is split dorsally, and the opened sinus is rotated to create an anterior vaginal wall (Fig. 104.9).

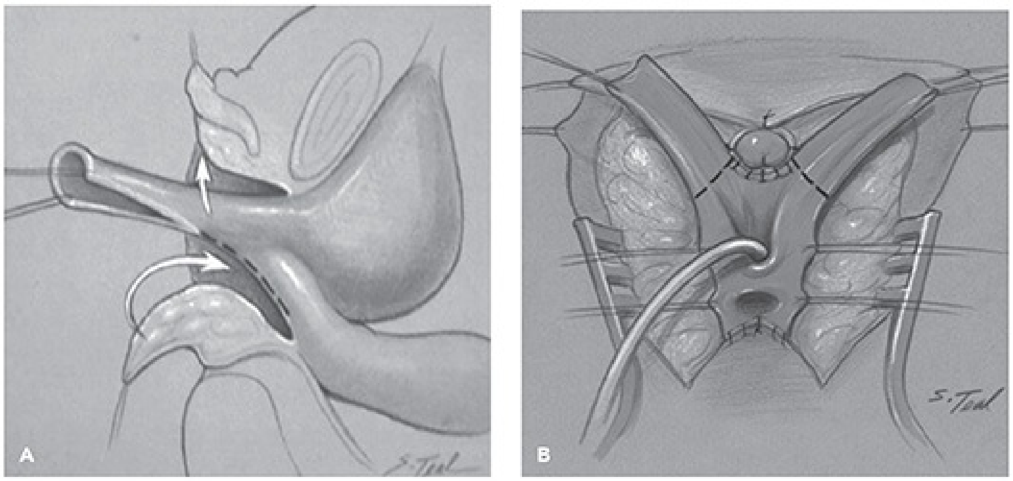

FIGURE 104.7 Low confluence with flap vaginoplasty. A: The mobilized sinus is opened on the ventral side. B: The opened sinus provides a mucosa-lined vestibule. *Arrows* indicate direction of tissue placement. (From Indiana University School of Medicine, Office of Visual Media, with permission.)

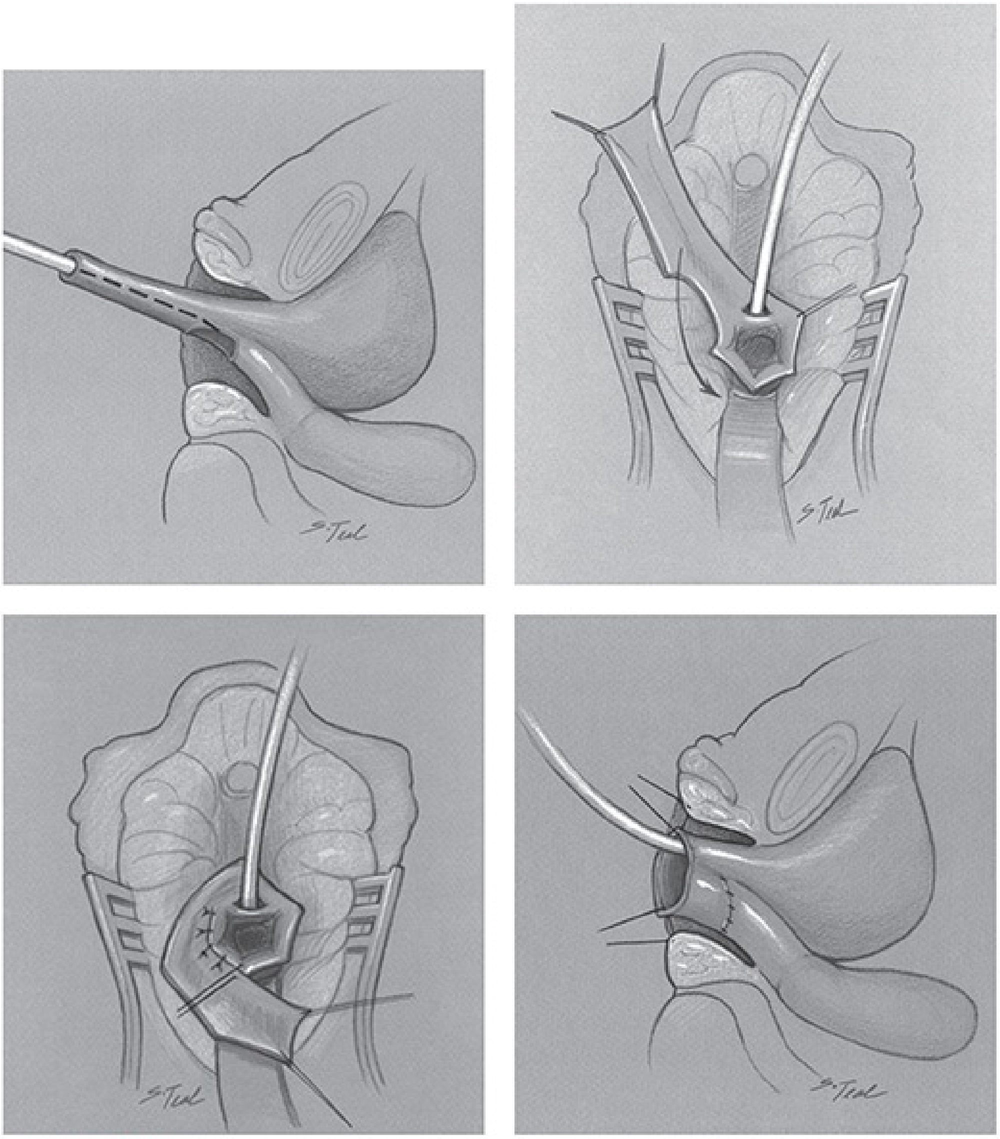

FIGURE 104.8 The mobilized sinus is split laterally to allow rotation of the flap to create a posterior vaginal wall. (From Indiana University School of Medicine, Office of Visual Media, with permission.)

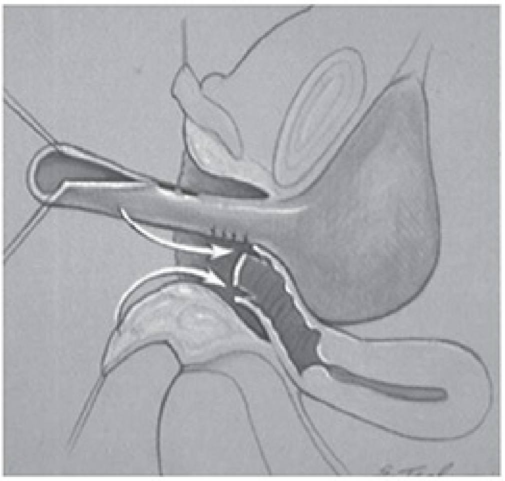

FIGURE 104.9 The sinus is opened dorsally for a pull-through vaginoplasty and rotated to create an anterior vaginal wall. *Arrows* indicate direction of tissue placement. (From Indiana University School of Medicine, Office of Visual Media, with permission.)

Due to concerns for potential sphincteric injury from aggressive retropubic dissection, Rink et al. (20) described *partial urogenital mobilization* (PUM). In the PUM, the dissection anteriorly ceases at the pubourethral ligament (Fig. 104.6B). We believe this procedure is less risky yet still allows use of the mobilized tissue for improved cosmesis and function as described previously for the TUM.

This concern for incontinence or sphincteric injury with TUM has been challenged (24,25). To date, no incontinence has been noted with TUM. In the majority of urogenital sinus anomalies, PUM is adequate to exteriorize the vagina when combined with a flap vaginoplasty.

OUTCOMES

This is a time of widespread evaluation of all aspects of feminizing genitoplasty. There is little agreement on any component, including the timing of the procedure or even the necessity of some aspects, such as clitoroplasty. While virtually all surgeons believe they achieve excellent cosmetic results, blinded studies have questioned this. Unfortunately, there are few data available on long-term results from current surgical techniques. There is debate about both the psychological aspects of having genital surgery and the psychological aspects of not having the surgery and growing up with genital ambiguity. Clitoroplasty is controversial, as no one knows if it is a clinical problem to have an enlarged clitoris, and there remains a concern that even modern techniques may alter sensation. Certainly secondary clitoral surgery has very high risks. Risks of decreased temperature and vibratory sensitivity have been described with concerning frequency (26). Vaginal stenosis following vaginoplasty requiring secondary vaginoplasty has been reported in 30% to 90%. Although we believe current techniques will improve the results, long-term studies are needed. Should the parents make the decision about early surgery, or should it be postponed until the patient can decide? If the latter, then what are the social implications of growing up with ambiguous genitalia? Virtually all agree that the vagina must be exposed to allow egress of menstrual fluid, but when this should be done remains controversial. Surprisingly, there is little evidence that a urogenital sinus effects menstrual flow. We have encountered adult patients without surgery who have no problems with their menstrual flow. Early TUM results are promising, and incontinence does not seem to be a problem in children who are otherwise neuroanatomically normal. The procedure is technically easier. The results now 15 years after the original description of TUM have not shown incontinence to be a problem (24). True long-term results and potential for stress incontinence remain unknown. Early PUM results are similarly promising with no incontinence and excellent cosmetic results. All neurologically normal children older than 2 years who have undergone PUM in our hands are dry and voiding. These issues are complex and will only be solved by long-term prospective multi-institutional studies. We believe that virtually all CAH patients can be treated with a PUM technique, avoiding the more aggressive TUM.

From an anatomic and cosmetic standpoint, surgical reconstruction of cloacal anomalies is now satisfactory in the majority of cases. Unfortunately, the functional success of the urinary and rectal elements of the reconstruction also depends upon sacral nerve function and the quality and innervation of the sphincteric complexes. The bladder neck and intrinsic sphincter may be inherently deficient with a high confluence. No natural plane exists between the bladder neck or trigone and the vagina, and therefore, the continence mechanism may be further compromised as the vagina is dissected off the bladder neck. The external sphincter may also be congenitally deficient or may be injured during reconstruction. Due to abnormal sacral nerve function, these patients may require intermittent catheterization or further reconstruction, such as outlet resistance enhancement or augmentation cystoplasty, to achieve continence (27).

Outcomes of vaginoplasty in cloacal anomalies are as reported with the high-confluence urogenital sinus. TUM appears to reduce the incidence of stenosis and the need for a pull-through procedure, although long-term pubertal follow-up is pending. Introital revision may be required at puberty after vaginoplasty in infancy.

One of the most important issues in functional outcome after repair of a persistent cloaca is the long-term preservation of renal function. Many of these children have congenital renal dysplasia related to vesicoureteral reflux and/or in utero infravesical urinary tract obstruction. Persistent postnatal hydronephrosis should be aggressively addressed with diversion if necessary. Chronic renal failure may occur even in the fortunate subset of patients who achieve a normal nadir creatinine in infancy (28). This is usually due to abnormal lower urinary tract dynamics. Therefore, even after apparently successful lower urinary tract reconstruction, these patients require urodynamic evaluation and vigilant monitoring to prevent upper urinary tract deterioration due to silent bladder dysfunction.

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CHAPTER 105 ■ SURGERY TO CORRECT AMBIGUOUS GENITALIA (46XX DISORDER OF SEXUAL DEVELOPMENT)

ANTHONY J. CASALE

Ambiguous genitalia and *intersex* are historical terms used to describe a congenital condition where the appearance of the genitalia is neither classically male nor female. Modern nomenclature has been proposed to replace the old, and this group of disorders is now described as disorders of sexual development (DSD). The condition affects both external genitalia (phallus, labia, scrotum, and introitus) and internal reproductive structures (vagina, urethra, urogenital sinus). In these cases, there is usually a conflict between the genetic sex, gonadal sex, and apparent gender as based on genital appearance. The genital appearance may be gender neutral and give little indication of the genetic or gonadal sex. On the other hand, the genitalia may have an appearance more consistent with the opposite gender, as with females with severely virilized congenital adrenal hyperplasia (CAH). When patients with these conflicts reach adulthood, they face significant hurdles in both reproduction and sexual activity.

The historical goal of surgery for ambiguous genitalia has been to provide the child with genitalia that have the appearance of and are functional as either male or female gender and that are consistent with the genetic and gonadal sex when possible. *Feminizing genitoplasty* is the term used to describe a series of surgical procedures designed to create classic female genitalia from a truly ambiguous genital state. This surgery has usually been applied to female patients with partially masculinized genitalia, and in those cases, surgery brings the genetic, gonadal, and genital sex back into alignment. Rarely, this surgery has been used to reassign the gender of genetic and gonadal male patients with what was felt to be inadequate phallic tissue to the female gender. It is this later group of patients who have had more difficulties with gender dissatisfaction and their experience has brought the principle of gender assignment under question. This chapter will discuss the technical aspects of feminizing genitoplasty.

Society dictates that the appearance of the infant’s genitals and therefore its apparent gender is the subject of great and urgent interest for the immediate and extended family and friends, making ambiguous genitalia a cause of intense concern and confusion for all. It is this powerful interest that has driven physicians and families to treat the condition as an emergency, even though there are often no immediate health risks. The historical approach to this issue has been to assign gender based on several factors, including the potential for reproduction, the technical limits of surgical reconstruction (i.e., our limited ability to create a male phallus without adequate corpora), and the belief that gender was determined by genital appearance and role assignment in childhood. The validity of this approach has recently been questioned and is the subject of widespread study at this time. At present, intrauterine and postpartum androgen exposure of the central nervous system seems to be the dominant factor in determining gender identity. Exactly how to reliably measure the gender of the brain remains an unsolved question.

Genital ambiguity is a result of an abnormality in sexual determination resulting from a defect in genetic, gonadal, or genital tissue differentiation and has been classified historically into four categories: female pseudohermaphrodite (now called 46XX DSD), male pseudohermaphrodite (46XY DSD), mixed gonadal dysgenesis (sex chromosome DSD), and true hermaphrodite (ovotesticular DSD). Female genital reconstruction, also called feminizing genitoplasty, is restricted to female pseudohermaphrodite (46XX DSD), mixed gonadal dysgenesis (sex chromosome DSD), and true hermaphrodite (ovotesticular DSD) individuals who have the potential to have normal female sexual function. CAH is a form of 46XX DSD and is by far the most common condition causing ambiguous genitalia. CAH is responsible for over 70% of cases of ambiguous genitalia and the vast majority of patients treated with feminizing genitoplasty.

Candidates for feminizing genitoplasty have two distinct problems: (a) the fusion of their internal reproductive system with the urinary tract as a urogenital (UG) sinus with a single external orifice and (b) the virilization of the external genitalia, with fused labioscrotal folds and clitoral enlargement. The internal anatomy can cause problems by pooling of urine within the vagina and uterus and inadequate vaginal drainage for secretions and menses. There is no adequate external vaginal orifice for sexual intercourse. Infants with a UG sinus may present with urinary infection or an abdominal mass from a poorly drained vagina or uterus. Today, many present on prenatal ultrasound screening that reveals a dilated bladder, vagina, or upper urinary tract. The external genitalia are a concern primarily for sexual function and the potential psychological damage that may result from gender ambiguity.

There have been great advances in the surgical technique of feminizing genitoplasty over the past half century, resulting in more normal appearance and sexual function. Despite apparently successful surgery, some adult patients have expressed profound dissatisfaction with their childhood genital reconstruction and gender. Because of this concern, more long-term outcome studies that include all patients with these rare conditions must be undertaken in order to understand the most appropriate management of these complex patients. The challenge of these studies is to make them comprehensive in surveying medical, sexual, and psychological health.

The first task for the physician faced with a child with intersex is to correctly diagnose the underlying condition responsible for the appearance of the genitalia. A team including a pediatric urologist, pediatric endocrinologist, neonatologist, and either pediatric psychologist or psychiatrist provides the best approach for this complex process.

The first step in diagnosis is a thorough physical examination. The initial caregivers in the nursery are usually alerted to the possibility of gender ambiguity if the phallus is small or curved and if the labioscrotal folds are partially fused (Fig. 105.1). The pediatric urologist should then document the length and diameter of the phallus and the position and number of external perineal openings, including the position of any potential UG orifices as well as the rectum. The state of fusion of the labioscrotal folds and their location are important, as is the presence or absence of palpable gonads. The presence of a palpable gonad almost always is consistent with male gender. Hyperpigmentation of the labioscrotal skin is common in cases of CAH. The blood pressure should be measured carefully because of the threat of hypertension with CAH.

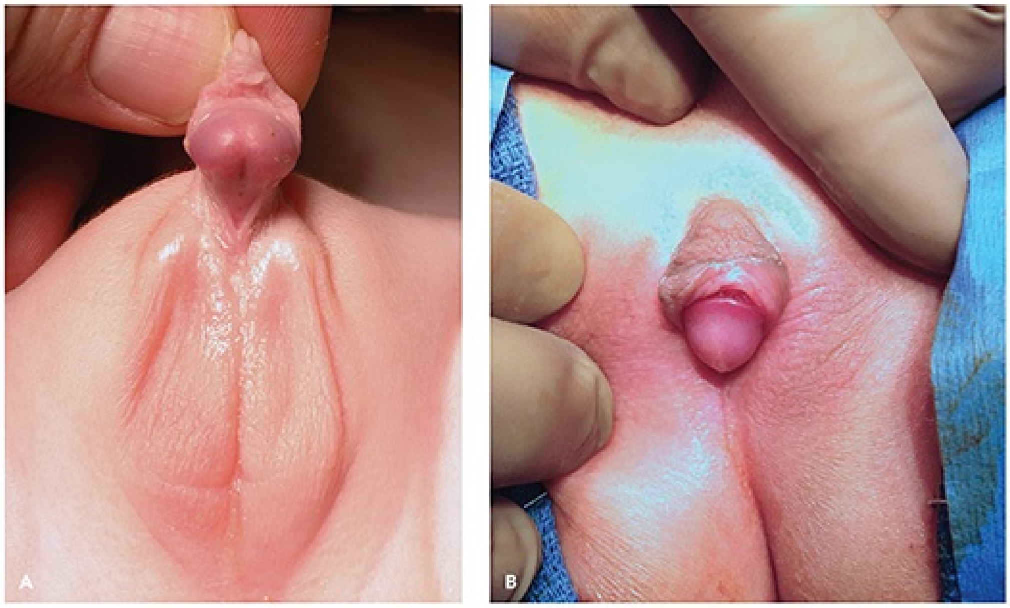

FIGURE 105.1 A and B: These intersex female patients demonstrate labial/scrotal fusion and a hypertrophied phallus with a distal UG sinus opening.

Chromosomal studies should be sent immediately. In the immediate newborn period, the presence of functioning testicular tissue can be determined by measuring serum testosterone, which is elevated in the first few days of life. CAH is diagnosed by finding elevated plasma levels of 17-hydroxyprogesterone and androstenedione and urine levels of pregnanetriol and 17-ketosteroids. CAH can be a life-threatening condition because adrenal insufficiency commonly causes salt wasting leading to hyponatremia and hyperkalemia and could result in lethargy, vomiting, and eventual hypotension.

Imaging studies of the infant should include a pelvic ultrasound looking for the presence of a uterus and retrograde injection of contrast into the UG sinus (genitogram) to identify the presence of a vagina and uterus. The uterus can usually be identified on pelvic ultrasound of the newborn as a 1-cm solid midline mass just posterior to the bladder (Fig. 105.2). The uterus can often be identified on a genitogram with a cervical impression outlined by the contrast in the vagina.

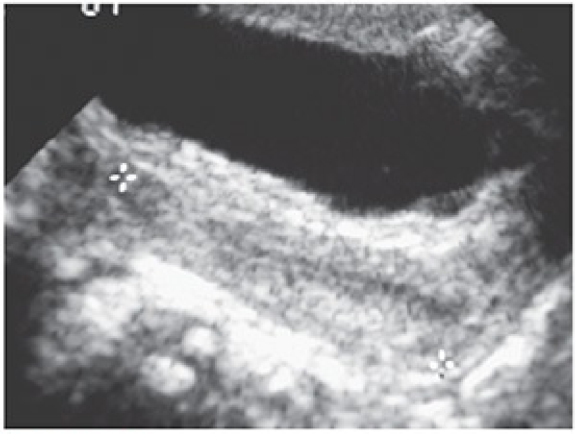

FIGURE 105.2 Pelvic ultrasound demonstrates the uterus in the midline position posterior to the urinary bladder.

During the initial investigation, the family is advised to delay naming the child and reporting the child's gender to others until the gender is established and to state only that the child had some developmental problems that need to be investigated. It is during this period that the gender assignment team should carefully educate and counsel the family about the nature of their child's problem and the limitations and potential inherent in the exact condition. The family should be prepared to face the options of therapy, including reconstructive surgery, so that when the diagnosis is clear, they can make an informed decision. This is a difficult and often painful process for both family and team, and it is critical that every option be explored and discussed with the family and that this counseling is documented in the medical record.

There are actually two decisions to be made by the parents: the gender that they will raise the child and whether to have reconstructive surgery. Gender decisions have always been considered urgent, while surgical reconstruction decisions may be made later as long as there is not a health concern because of inadequate drainage of urine. The medical team must explain the surgical options, including advantages, risks, and potential complications of delaying surgery, performing the external genital reconstruction (clitoroplasty), and performing the internal genital reconstruction (UG sinus repair).

TIMING OF SURGERY

Once the decision for feminizing genitoplasty has been made, the timing of the procedure is of some importance. In cases of CAH, glucocorticoid and mineralocorticoid replacement therapy will diminish androgen production by the adrenal and lead to partial reversal of the clitoral hypertrophy. For this reason, the external genital surgery should be delayed until at least 6 months of age. In some cases, hormone replacement therapy decreases the size of the clitoris so that surgery on this structure is not necessary. Since most complaints about childhood genital surgery involve dissatisfaction with clitoral reconstruction, most surgeons have currently limited this surgery to the most extreme cases of enlargement and with the family’s clear support. Some surgeons have refused to perform clitoral reconstructive surgery altogether. The decision about clitoral reconstruction is the most difficult issue to face in the care of these children and must be considered carefully by the family and medical team.

Some surgeons prefer to delay reconstruction of the internal structures until adolescence if the child does not have problems with urine retention and urinary tract infections because historically, patients who had reconstruction early in life might require a secondary procedure at adolescence to correct vaginal stenosis. On the other hand, those children who have early reconstruction need only dilations or simple revisions of the vagina at adolescence, in contrast to the child who delays the major reconstruction until later in life. We prefer to do a complete reconstruction at 6 months of age and explain to the family that a second minor procedure may be needed later.

PREOPERATIVE EVALUATION

Each child suspected to have ambiguous genitalia should have a complete anatomic, endocrine, and genetic evaluation. A karyotype is necessary not only to determine the correct genetic sex but also to look for other chromosomal errors that may be present. A complete endocrine evaluation should focus on potential gonadal function as well as concerns related to the endocrinopathy of CAH.

A comprehensive definition of the anatomy is imperative in planning for and accomplishing the reconstruction. The upper urinary tract should be imaged with ultrasound and, if the kidneys are not normal, a diuretic (Lasix) renal scan. The lower urinary tract should be imaged with a retrograde genitogram (Fig. 105.3). This is performed by placing a catheter in the most distal portion of the UG sinus and injecting contrast while imaging from the anterior, lateral, and oblique perspectives. This gives the surgeon important information about the length of the UG sinus, the point of confluence of the vagina and urethra, and their relative lengths and position within the pelvis. The level of this confluence, either high (UG sinus over 3 cm) or low (UG sinus <3 cm), ultimately determines the surgical approach. Further imaging of the pelvic organs may be necessary in complex cases and can be done with magnetic resonance imaging or computerized tomographic scanning with good visualization.

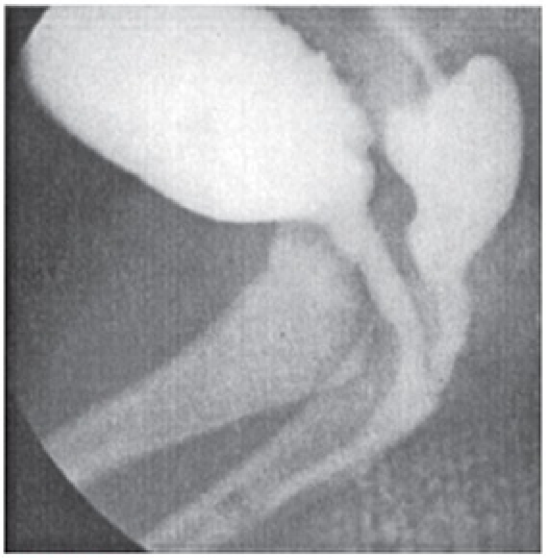

FIGURE 105.3 Genitogram demonstrates confluence of the urethra anteriorly and vagina posteriorly. Note cervical impression at the apex of the vagina and contrast within the cervix.

Finally, an examination under anesthesia is needed, including cystoscopy and vaginoscopy. It is often easier to measure the length of the UG sinus and determine the height of the confluence with the scope than with imaging. The length of the UG sinus can be measured by placing the tip of the scope at the point of confluence and marking the scope at the level of the external meatus. When the scope is withdrawn, the length of the UG sinus is estimated by measuring the distance from the mark on the barrel to the tip of the scope. These measurements of the UG sinus, vagina, and urethra, along with the position of the confluence of all three, are important in order to plan what techniques may be necessary for repair.

SURGICAL POSITIONING

Most of the surgery for ambiguous genitalia can be performed in the lithotomy position. The lithotomy position is ideal for the clitoroplasty and reconstruction of the labia and introitus. The lithotomy position, however, does not always provide adequate exposure of the higher forms of UG sinus. Hendren and Atala (1), Peña (2), and Rink and Adams (3) have demonstrated the superior exposure provided by the posterior prone approach to the pelvic organs. We follow Hendren's recommendations to prepare the patient circumferentially while applying sterile wrapping to the lower legs to allow the patient to be turned from the lithotomy to the prone position as necessary during the operation. It is wise to have all positioning options available for this challenging surgery. Surgery usually begins in the lithotomy position and the clitoroplasty is done first, followed by the vaginoplasty, and finally the labioplasty.

SURGICAL TECHNIQUE

Repair of the External Genitalia

Clitoroplasty

Once the decision has been made to surgically reconstruct the clitoris, the goal of clitoroplasty is to reduce the size of the enlarged clitoris to one that is within the range of normal for females. Modern clitoroplasty developed after Mollard et al. (4) realized that the erectile tissue of the corpora was primarily responsible for the large size of the organ and that it caused problems during sexual engorgement. The glans clitoris must be preserved for sensation, but the corpora should be shortened. Mollard mobilized the neurovascular bundle that supplied the glans and excised the corpora from the level of their union at the pubis to the distal tip. He then sewed the glans back to the stumps of the corpora cavernosa, resulting in a functional clitoris that could become engorged to an appropriate size and was sensate. The dissection of the neurovascular bundle is somewhat difficult and can potentially lead to compromise of the nerves or infarction, so we prefer a variant of the Mollard procedure that was described by Gonzalez and Fernandes (5).

A circumferential incision is made on the clitoris just proximal to the coronal sulcus, and the clitoris is degloved from skin and subcutaneous tissue. The urethral plate and rudimentary corpus spongiosum may be divided distally and dissected with the subcutaneous tissue or just mobilized from the corpora cavernosa while leaving it attached both proximally and distally. We prefer to divide the urethral plate from the glans during this dissection. Incisions are made in the tunica albuginea of the corpora at the 2 and 10 o'clock positions using needle-point electrocautery. These incisions are extended and joined across the ventral aspect of the corpora at the subcoronal level distally and 0.5 cm above the pubis proximally (Fig. 105.4). The dorsal tunica albuginea (including the enclosed neurovascular bundle) is dissected from the erectile tissue and remaining tunica of the corpora. The erectile tissue bodies and their ventral and lateral fascia can be dissected from the dorsal fascia and excised. A 4-0 polyglycolic acid suture can be used to ligate each corporal body at its base. The rim of fascia on the glans can be sewn to the fascia on the stumps of the corpora with 4-0 suture to reseat the glans and stabilize it. The dorsal fascia, which contains the neurovascular bundle, is allowed to fold under the skin cranial to the glans. The urethral plate, which was previously separated from the glans, can now be shortened and partially split in the midline to flatten the introitus and to shorten the distance from the vagina to the clitoris (Fig. 105.5).

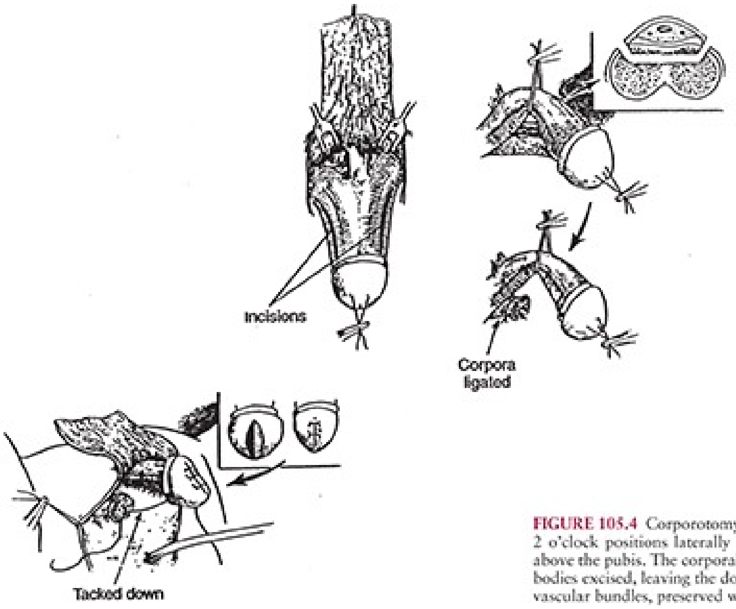

FIGURE 105.4 Corporotomy incisions are extended from the 10 and 2 o'clock positions laterally from just below the corona to 0.5 cm above the pubis. The corporal bodies are ligated at their base and the bodies excised, leaving the dorsal strip of fascia, including the neurovascular bundles, preserved with the glans.

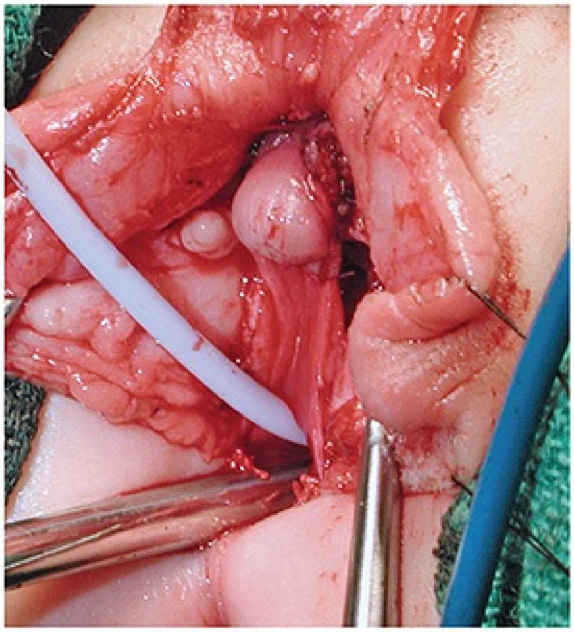

FIGURE 105.5 The urethral plate is used to shorten the distance between the clitoris and the vagina, producing a more normal introitus.

The glans clitoris is often quite large, and several procedures have been described to reduce its size. We have preferred not to decrease the overall size of the glans but instead to conceal some of the dorsal glans with the glans hood. A small patch of the dorsal glans epithelium at the base can be excised, leaving the erectile tissue intact, and the glans hood can be sewn to this area and allowed to fold over the remainder of the glans. This leaves the glans with its full erectile capability, leaves it accessible, and covers it appropriately with a skin hood.

Labioplasty

The goal of labioplasty is to create a normal-appearing and normal-functioning female perineum and introitus. The shaft skin and dorsal prepuce of the clitoris can be utilized to form the labia minora and to fashion a clitoral hood. The original skin incision had degloved the clitoris and left all skin based on the dorsal pedicle. This skin can then be split in the midline for approximately two-thirds of its length (Fig. 105.6). At the proximal end of the incision, a transverse incision is made and curved proximally at each end for a few millimeters to develop a flap that is used for the clitoral hood. The two long sides of the shaft skin are folded to form long, thin, vertical two-sided flaps that will form the labia minora. The horizontal central flap is folded under itself to form a two-sided hood for the clitoris. The clitoral hood is sewn to the base of the dorsal aspect of the clitoris and around each side to the approximate 3 and 9 o’clock positions. Each of the three flaps is sewn into shape using 5-0 absorbable suture.

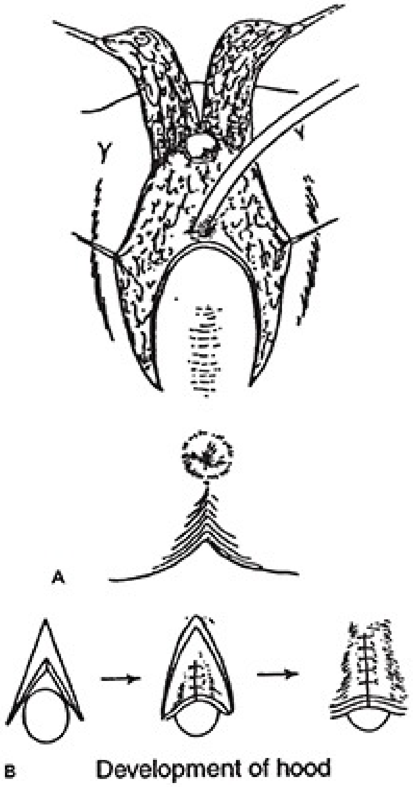

FIGURE 105.6 **A:** The clitoral shaft skin is mobilized and partially split in the midline. **B:** The skin is then folded down toward the vagina. The dorsal aspect of the skin is folded on itself to form a two sided dorsal hood over the clitoris and the ventral skin is sewn together side to side and then sewn to the vagina and labial scrotal skin to form labia minoria.

The labia minora are created with the two lateral strips of shaft skin. They are dissected on their pedicles to allow them to extend to the vagina or midperineum (Fig. 105.7). They are then sewn to the lateral aspect of the urethral plate, which now lies in the midline between vagina and clitoris. A three-way stitch is used to fasten the labia minora to the introitus and to narrow their base so that they maintain their character and their base does not spread and flatten. The labioscrotal folds are then sewn to the labia minora to form the labia majora. All sutures are absorbable 4-0 and 5-0, and while some suture lines can be created using a running 5-0 suture, any point of potential tension, such as at corners, should be fixed with an interrupted 4-0 skin suture.

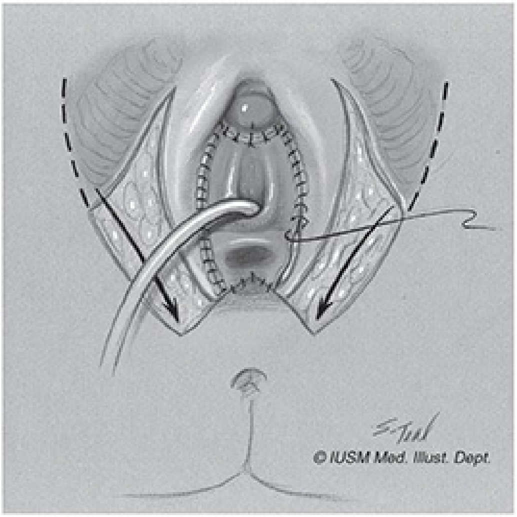

FIGURE 105.7 The dorsal preputial skin flaps are mobilized laterally and advanced toward the vagina (*arrows*). There, they are sewn to the lateral edge of the urethral plate as a labial flap. The labioscrotal folds are then sewn to the lateral edge of the labia minora to form labia majora.

Repair of the Urogenital Sinus

Low-Confluence Urogenital Sinus

The goal of UG sinus reconstruction is to create separate functional openings for the urinary and genital tracts. The low-confluence UG sinus has a long urethra and vagina that join near the perineal surface, resulting in a short common channel or sinus (Fig. 105.8). There are two good options for managing these anomalies. John Lattimer introduced the posterior flap vaginoplasty in 1964, and it is still a useful technique (6).

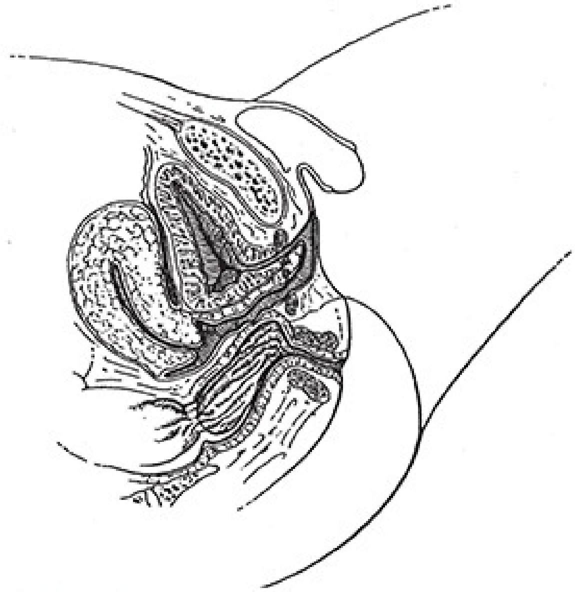

FIGURE 105.8 This illustration demonstrates a low-confluence UG sinus with a short common UG sinus channel draining the urinary bladder and vagina.

A U-shaped incision is made in the perineum with the open end facing caudally and the proximal point at the orifice of the UG sinus. This incision isolates a posteriorly based skin flap (Fig. 105.9). This flap was originally designed to be wide-based but it needs to be no wider than half of the circumference of the proposed vagina (a 1- to 1.5-cm flap in infants). The excellent blood supply of the tissue allows a narrower flap, which results in a more normally functional and cosmetic introitus.

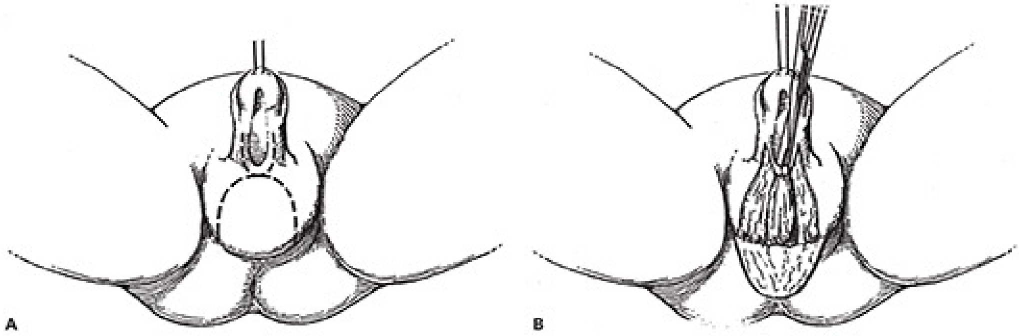

FIGURE 105.9 A: Inverted U incision. B: Posterior-based perineal skin flap used to widen and change the angle of the poster wall of the vagina.

Once the skin flap is isolated, it is mobilized from the deeper tissue and folded back to expose the caudal wall of the UG sinus (Fig. 105.10). A fine-tipped hemostat can be placed in the orifice and the sinus split using electrocautery in the midline to the level that exposes the confluence of the sinus vagina and urethra. The vagina is split as deep as the apex of the posterior skin flap will reach. With a catheter in the urethra, the posterior skin flap is sewn in position starting at the apex and using interrupted absorbable 4-0 sutures. This advancement of the flap into the sinus and vagina both widens the introitus and the vagina and reorients the vagina into a more vertical position, improving passive drainage (Fig. 105.11).

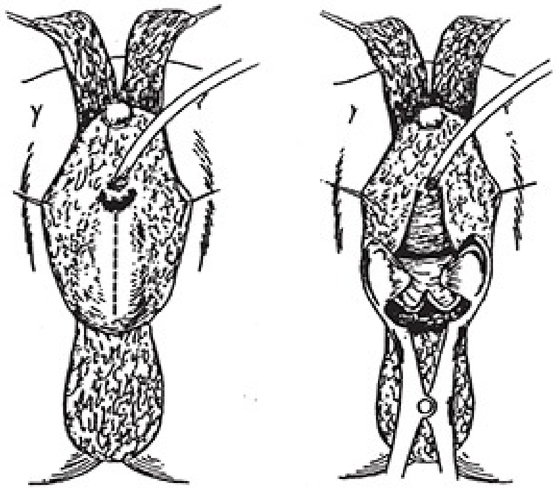

FIGURE 105.10 The caudal portion of the UG sinus is exposed by deflecting the perineal skin flap inferiorly. The sinus can then be mobilized intact or split in the midline ventrally to the level of the vagina in a very low confluence case.

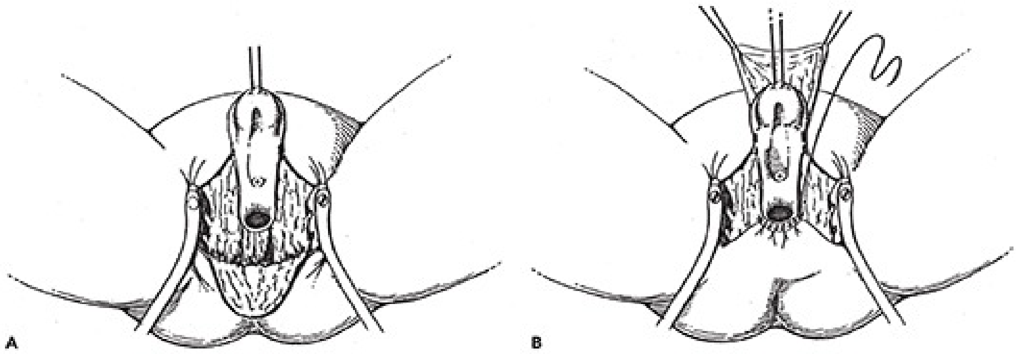

FIGURE 105.11 A: The posterior vaginal wall can be split in the ventral midline. B: The perineal skin flap advanced to form the posterior wall of the vagina tow widen it and make the introitus more vertical.

The other option for the low UG sinus is a limited total urogenital mobilization (TUM) technique as described originally by Peña (2). This is a relatively simple technique and is initiated by a circumferential incision around the UG sinus orifice (Fig. 105.12). This dissection is continued around the sinus while providing constant traction on the sinus with multiple stay sutures. The entire sinus vagina and urethra can then be mobilized caudally, delivering the confluence of the urethra, vagina, and sinus to the level of the perineal skin (Fig. 105.13). Peña (2) originally described this technique for use in cloacal reconstruction and stressed that the dissection must extend high in the pelvis, but this is not always necessary in the low-confluence UG sinus. The dissection can be considered complete when the confluence is at the level of the perineum.

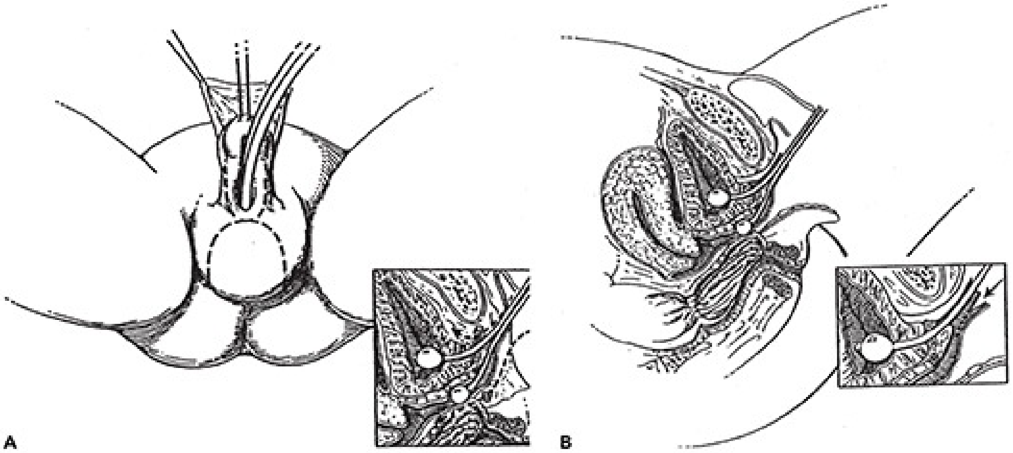

FIGURE 105.12 A: Total urogenital sinus mobilization (TUM) for the UG sinus begins by circumferential dissection around the common channel. With cranial dissection, the entire sinus can be mobilized and delivered to the level of the perineal skin. *Inset*, Fogerty baloon catheters are helpful in guiding dissection. B: If the vagina reaches the perineum easily, the excess sinus can be amputated. *Inset*, if the vagina is narrow, it can be split in the midline posteriorly and the posterior perineal skin flap inserted as part of the posterior vaginal wall.

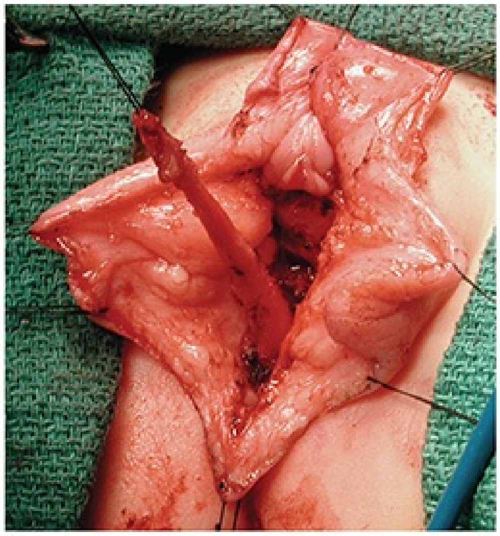

FIGURE 105.13 Total UG sinus mobilization for the high UG sinus requires a more extensive circumferential cranial dissection that takes down all the attachments to the pubic bone.

If the vagina and urethra reach the appropriate level and are wide enough to be functional, then the distal UG sinus can be amputated and discarded (Fig. 105.14). If the vagina is too narrow, the posterior wall of the vagina can be split and a posteriorly based perineal skin flap can be inserted to widen it.

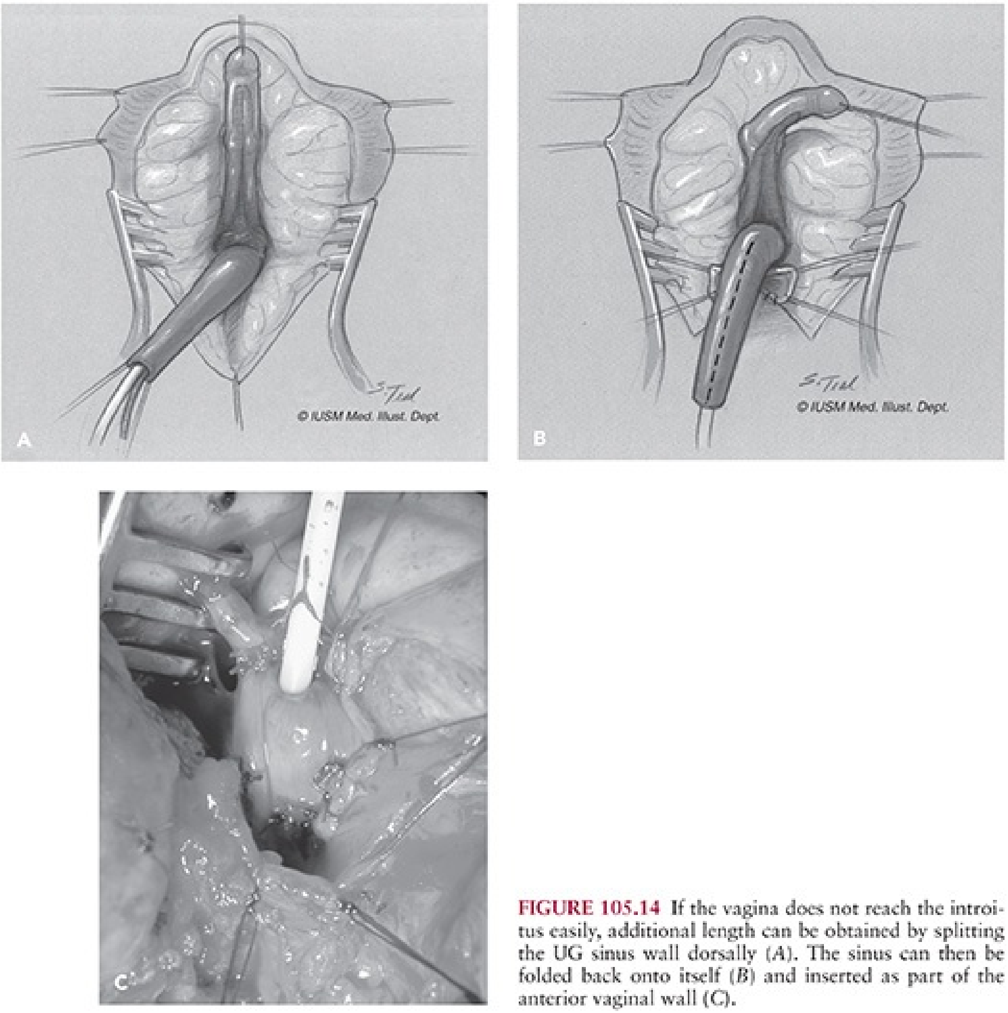

FIGURE 105.14 If the vagina does not reach the introitus easily, additional length can be obtained by splitting the UG sinus wall dorsally (*A*). The sinus can then be folded back onto itself (*B*) and inserted as part of the anterior vaginal wall (*C*).

High-Confluence Urogenital Sinus

The high-confluence UG sinus with a short urethra and vagina and a long common UG sinus channel is much more of a challenge to reconstruct because of the position of the confluence high within the pelvis and the relative lack of suitable tissue for reconstruction. In this condition, the urethra and vagina are short and tethered far from the introitus by soft tissue attachments within the pelvis.

Early attempts to repair these children were made using techniques that were more suitable for low-confluence variants, and this fact may explain many of the poor surgical results now apparent in older patients. The posterior flap repair, which was very useful for less severe cases, did not provide enough length to reach the high confluence and left the child with a short, hypospadiac urethra, and inadequate tissue to reconstruct the vagina to the introitus. Hendren pioneered the dissection separating the bladder and vagina, allowing the vagina to be advanced toward the perineum. This dissection between the urinary and genital tract is very difficult and can result in vesicovaginal fistula and bladder dysfunction. Even with the vagina completely dissected from the posterior bladder, it often would not reach the perineum, and the gap was bridged with complex skin flaps that were sometimes less than ideal.

Peña’s (2) TUM procedure is a perineal-based approach that is based on circumferential dissection of the UG sinus, vagina, and urethra and advancement of these structures toward the perineal surface. This approach leaves the child with a urethra of normal length by lowering the bladder and vagina in the pelvis. The TUM also lowers the proximal vagina and uterus in the pelvis, allowing the vagina to be reconstructed with less outside tissue. The TUM has become an important tool in the reconstruction of children with UG sinus, particularly those with a high confluence (7).

The initial circumferential dissection around the UG sinus is performed just as with the lower confluence variant. Multiple stay sutures are placed and the dissection can be performed in the lithotomy position. Unlike the lower confluence UG sinus, those who have a high confluence need much more extensive dissection to allow the vagina to come close enough to the perineum for satisfactory reconstruction. The dissection usually must reach the level of the pubis both anterior and posterior to the UG sinus.

If the vagina and urethra reach the appropriate level and are wide enough to be functional, then the distal UG sinus can be amputated and discarded (see Fig. 105.14). This is usually not the case, however, and the distal vagina is usually too narrow. In this case, the vagina can be divided from the sinus, dissected away from the urethra and bladder, and split in the midline dorsally. The mobilized sinus can also then be split in the midline dorsally and the sinus can be folded back on itself ventrally and advanced into the vagina as a flap to widen the vagina (8). If the vagina is still too narrow, the posterior vaginal wall can be split as well and a posteriorly based perineal skin flap can be inserted (see Fig. 105.11). The TUM has allowed UG sinus reconstruction and minimized the need to perform the difficult dissection between bladder and vagina.

We prefer to approach the child with high UG sinus as an individual who may need various techniques for successful repair. The options are TUM, mobilization of the vagina from the urethra/bladder, and various flaps to augment the vagina from either the UG sinus tissue or perineal skin. The less severe cases may need only TUM and a posterior skin flap, while the most severe cases need all techniques in order to have a successful outcome.

Dressing and drains are strictly up to the surgeon and the difficulty of the procedure. A simple genitoplasty may need only antibiotic ointment or, at most, overnight catheter drainage. More complex procedures always merit catheter drainage of the bladder, and complex vaginoplasties may be aided with a vaginal Penrose drain or in some cases a pressure dressing of fluffed gauze and elastic tape crisscrossing the perineum. Some surgeons believe in keeping these patients in bed and relatively immobile for 48 hours, but we often allow them to move about at will and to be held by their mother immediately after surgery.

OUTCOMES

Complications

The most common complication of genitoplasty is bleeding, both immediate and delayed. The tissue is very vascular and the use of injected dilute epinephrine during the procedure may be helpful. Late bleeding may originate from the corpora cavernosa or vaginal wall and can usually be controlled with pressure dressing. Pressure dressing must be carefully applied since it is possible to cause vascular compromise of the glans clitoris in the immediate postsurgical period.

The neurovascular pedicle of the glans clitoris can be injured during the original dissection. This potential injury is minimized by leaving the entire dorsal fascia, including the bundles, intact during and after dissection. Infections in the urine or wound are also possible but uncommon. It is not unusual to find a small dehiscence of the wound at the posterior apex of the labial incisions due to tension from movement. These heal without surgical intervention. They can be bathed normally and dressed with antibiotic ointment. The skin stress in this area is the prime reason to close with longer lasting absorbable sutures.

Results

At this time, surgical results are consistently good in terms of appearance and potential for function.

There are, however, few long-term outcome data for feminizing genitoplasty, and the studies that have been done are, by necessity, evaluating the surgical technique that was in fashion 25 years ago. The techniques have improved, and while we can see superior cosmetic and functional results in young children and adolescents treated more recently, we still need to observe and evaluate these patients as they mature (9–11).

The question of gender assignment is one of great importance and intense study at this time. While it is necessary to learn from our patients, we must learn from all of them and not focus on only those who have been dissatisfied with their treatment. We now know that gender identity is much more complex than to be dependent on genital appearance and gender roles. While we must continuously re-evaluate our management of these difficult problems, we should not lose faith in the ability of surgery to create UG structures that can function normally and have an appearance consistent with the classic norm of the human body. Feminizing genitoplasty, like all surgery, has demonstrated that the most difficult question remains the choice of the correct procedure for the proper patient.

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CHAPTER 106 CIRCUMCISION, CONCEALED PENIS, AND SCROTAL ABNORMALITIES

IRENE M. MCALEER AND GEORGE W. KAPLAN

Currently, about 1.2 million newborn boys and an unknown number of males beyond the newborn period in the United States are circumcised annually, probably making circumcision the most commonly performed surgical procedure on boys or men (1,2). It is estimated that 58% of hospitalized newborn males in the United States will be circumcised (3). The incidence of circumcision in the United States is highest in whites (88%) and less frequent in African Americans

(73%) and Hispanics (42%) (2). The frequency of newborn circumcision is much lower in other countries, such as Canada (35%) and Australia (10%), and is generally much less than 8% in Europe and most parts of Asia (1).

DIAGNOSIS

No diagnostic studies are needed preoperatively. Comorbidities, such as excessive prematurity, inherited or transient bleeding disorders associated with infancy, and congenital abnormalities of the skin such as epidermolysis bullosa and of the penis such as exstrophy, hypospadias, penoscrotal webbing, concealed penis (megaprepuce), or micropenis, would all mitigate against circumcision, particularly routine newborn circumcision (Fig. 106.1).

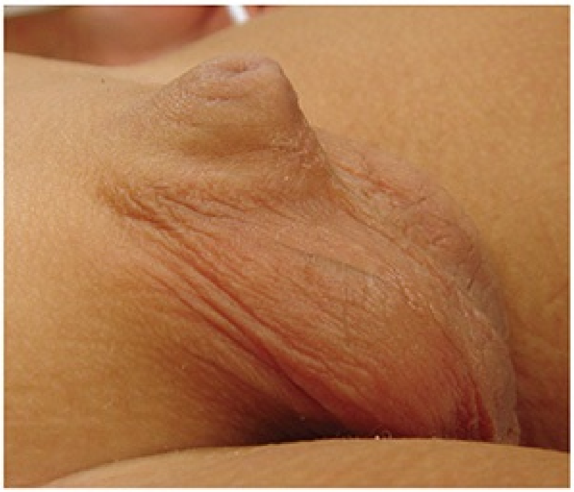

FIGURE 106.1 Webbed penis with paucity of shaft skin.

INDICATIONS FOR SURGERY

Circumcision is often performed in the neonatal period, infancy, or childhood for cultural or religious reasons and is also performed after the newborn period, when phimosis, paraphimosis, balanoposthitis, or sexually transmitted diseases are more prevalent. Medical benefits to the boy circumcised in infancy include reduced urinary infections in infancy (3,4), decreased incidence of sexually transmitted disease (2,5,6), and marked reduction in the incidence of penile carcinoma (7), but these benefits must also be weighed against the risks of the procedure: bleeding, infection, and poor outcome (8).

The American Academy of Pediatrics (AAP) in 1999 (9) concluded that there were benefits from neonatal circumcision, but the benefits gained did not warrant universal routine circumcision. Conversely, there are some opponents who feel that neonatal circumcision is never warranted (10). The AAP updated their review and recommendations concerning male circumcision in 2012. After an extensive 5-year review, the task force concluded that circumcision is a well-tolerated procedure with infrequent complications when performed by trained professionals under sterile conditions using appropriate pain management. Further, they found that the benefits of circumcision for preventive health outweighed risks associated with the procedure (11).

There is now fair evidence from studies in Africa that circumcision is protective against heterosexually acquired HIV infections in men. The average efficacy of reducing the risk of acquiring HIV in these studies was about 60% (3). The inner preputial skin in the uncircumcised man has more Langerhans cells than does the glans, outer preputial skin, or penile shaft skin. Langerhans cells have densely concentrated CD4 receptors used by HIV to bind to these receptors and enter the body. The retraction and telescoping of the inner preputial skin during intercourse facilitates HIV entry into the body (2,6). Male circumcision is also protective against syphilis, chancroid, and human papilloma virus (HPV) infections with a 30% to 40% reduction in risk of HPV infection in circumcised men compared to uncircumcised men (3).

Because circumcision is so common, there are a number of misguided ideas and practices that have evolved in American medical practice leading to some circumcisions being done for reasons that are not completely medically sound. At birth, the prepuce, in over 90% of infants, is fused to the glans and is not retractable. As studied by Gairdner in 1949 (12), the foreskin progressively retracts on its own with age, so that many preschool boys will have nonretractable foreskins that will spontaneously become retractable at some time before puberty. Oster et al. (13) found that only 1% of 17-year-olds will not have retractable foreskins. It is not necessary for parents or physicians to retract the prepuce as retractability occurs with penile growth, erection, and smegma formation; the smegma that forms will generally spontaneously be discharged from under the prepuce and does not need to be removed. Balanoposthitis is not a mandatory indication for circumcision in children as the prepuce in that area of the penis after such an episode will generally be separated from the glans and, once separated, should not produce recurrences of balanoposthitis. Occasional episodes of balanoposthitis should not be confused with the pathologic condition of balanitis xerotica obliterans (BXO). Forcible retraction of the prepuce causes the child pain and can produce paraphimosis or a dense cicatrix and perhaps subsequent BXO (Fig. 106.2).

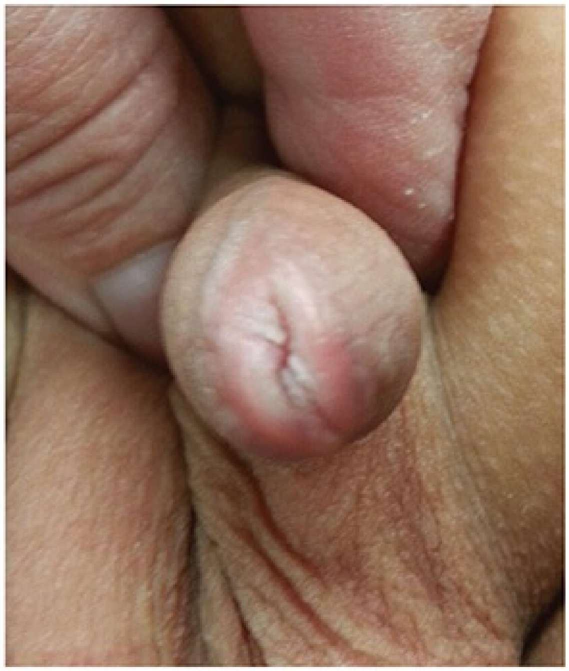

FIGURE 106.2 Photo of pathologic phimosis due to BXO.

Phimosis becomes pathologic when the opening of the foreskin develops a tight cicatrix often caused by BXO. According to Shankar and Rickwood (14), BXO represents the one absolute indication for circumcision. BXO is a chronic dermatologic condition of the prepuce and glans, analogous to lichen sclerosus et atrophicus, that can also involve the meatus and the anterior urethra, especially if the glans is extensively involved (15).

Most of the series of BXO in children have found that most of the patients affected are older boys, whose ages range from 5 to 15 years old (14–17). Previously, it was thought that the incidence of BXO was relatively rare in boys (range from 0.6% to 6%) (14,17), but recent reviews have shown that the BXO occurs more frequently in boys than previously reported. One recent study found BXO in a child who was only 2.5 years old, significantly younger than most reported cases (17). Circumcision alone is thought to be curative of BXO in 96% of cases, but it is concerning that in more obese boys, especially those with prominent pubic fat, more severe disease is prevalent and recurrent (17).

ALTERNATIVE THERAPY

Observation, intermittent medical treatment for balanoposthitis, and dorsal slit are common alternatives to circumcision. Recently, the use of topical steroid creams, typically 0.1% triamcinolone or 0.05% betamethasone cream (18–20), applied to the preputial opening for about 4 to 8 weeks has successfully treated phimosis and obviates the need for circumcision in 85% to 87% of boys reported to be using the steroid preparations.

Paraphimosis occurs when the prepuce with a tight preputial orifice becomes trapped behind the glans penis when retracted with resultant swelling of the glans that prevents its reduction. If untreated, paraphimosis can lead to infection, significant penile edema, pain, and, occasionally, loss of penile tissue. The edema can often be reduced by injecting hyaluronidase into the edematous tissue, thereby allowing for easier reduction of the paraphimosis. Alternatively, multiple punctures of the edematous prepuce with a hypodermic needle (after a penile block or analgesia is given) can relieve the edema, especially if manual pressure is applied after the punctures are made (21). Many health care providers are hesitant to inject anything or make multiple punctures into a swollen and painful penis, so another easy and effective treatment to reduce the paraphimotic edema is to place granulated sugar over the swollen penile tissue, producing an osmotic gradient that pulls the fluid out of the edematous prepuce (Fig. 106.3). Application of ice or application of a temporary pressure dressing can also be used to reduce swelling. Paraphimosis is then reduced by grasping the penis between the second and third fingers of both hands and pulling the shaft skin distally while simultaneously applying pressure to the glans with both thumbs. If this maneuver is unsuccessful, a dorsal slit is necessary to open the phimotic constriction ring. Circumcision can be performed after the inflammation and edema have resolved but should not be attempted at the time that the acute paraphimosis is present.

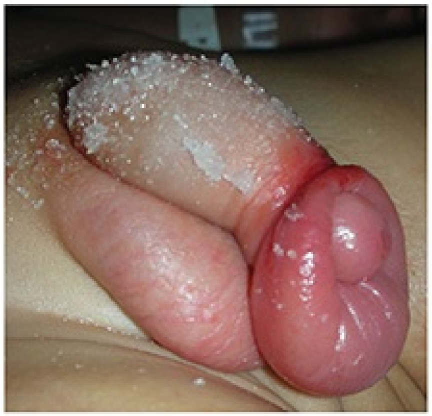

FIGURE 106.3 Photo of paraphimosis with topical granulated sugar.

Another alternative to a circumcision for pathologic phimosis is to perform a preputioplasty as either a triple incision procedure or a Y-V plasty on the dorsal surface of the prepuce. The triple incision involves three longitudinal incisions across the stenotic preputial ring down to the inner preputial layer with subsequent transverse closure of the three skin defects using absorbable suture which allows enlargement of the phimotic ring. The Y-V plasty can be performed by retracting the preputial skin to the corona (taking down the glanular adhesions to the prepuce), marking a “Y” incision from the inner preputial skin on the dorsum, incising the inner preputial skin on the marked “Y,” and advancing and closing the inner skin as a “V” using absorbable sutures to enlarge the phimotic ring. Both of these methods allow the patient to remain uncircumcised, if this is preferred, but both methods may form scar bands requiring an eventual formal circumcision (21).

SURGICAL TECHNIQUE

The goal of a circumcision is to remove an adequate amount of the prepuce such that the glans is exposed and balanoposthitis, phimosis, BXO, and paraphimosis are prevented. Too much or too little skin should not be removed, as the former can tether the penis and on occasion produce chordee, while the latter may produce continued risks of phimosis or paraphimosis.

All circumcisions should take place with an anesthetic: During the newborn period, local anesthesia with 1% lidocaine is generally used with or without topical anesthesia (EMLA 2.5% to 2.5% lidocaine–prilocaine). EMLA should be used cautiously in newborns, especially premature infants, as methemoglobinemia can occur. Other potential side effects from EMLA use include erythema, edema, or blister formation, and are more common in low birth weight infants who should probably have penile nerve blocks used instead (3). In older children and adolescents, general anesthesia is usually used. In adults and some adolescents, local anesthesia will often suffice. The penis is cleaned and draped and the foreskin retracted by taking down all the adhesions between the glans and the inner preputial skin. If a dense phimotic band prevents preputial retraction, a dorsal slit may be performed by placing one blade of a straight clamp inside the preputial opening in the dorsal midline (ensuring that the blade is not within the urethral meatus itself) and then placing the other blade on the outer skin. The clamp is closed and left in place for a few minutes, crushing the tissue and producing temporary hemostasis; the crushed area is then incised with scissors. Stretching the preputial opening gently with the hemostat clamp makes visualizing the urethral meatus easier and the dorsal slit may then be safely performed. Marking the coronal ridge (as seen through the shaft skin) in ink helps identify where to place the circumferential incision about the shaft skin. In the adult or older child, the proposed line of incision in the inner preputial sac is marked with ink about 3 to 4 mm below the coronal sulcus.

A common method of excising the prepuce, called a “sleeve technique,” is performed by incising the two previously marked lines of incision circumferentially about the penis and dividing the tissue between the layers. Hemostasis is secured generally with judicious use of either bipolar or monopolar cautery, although vessels can also be individually ligated. The skin and the inner preputial epithelium are then coapted with fine absorbable sutures (Fig. 106.4).

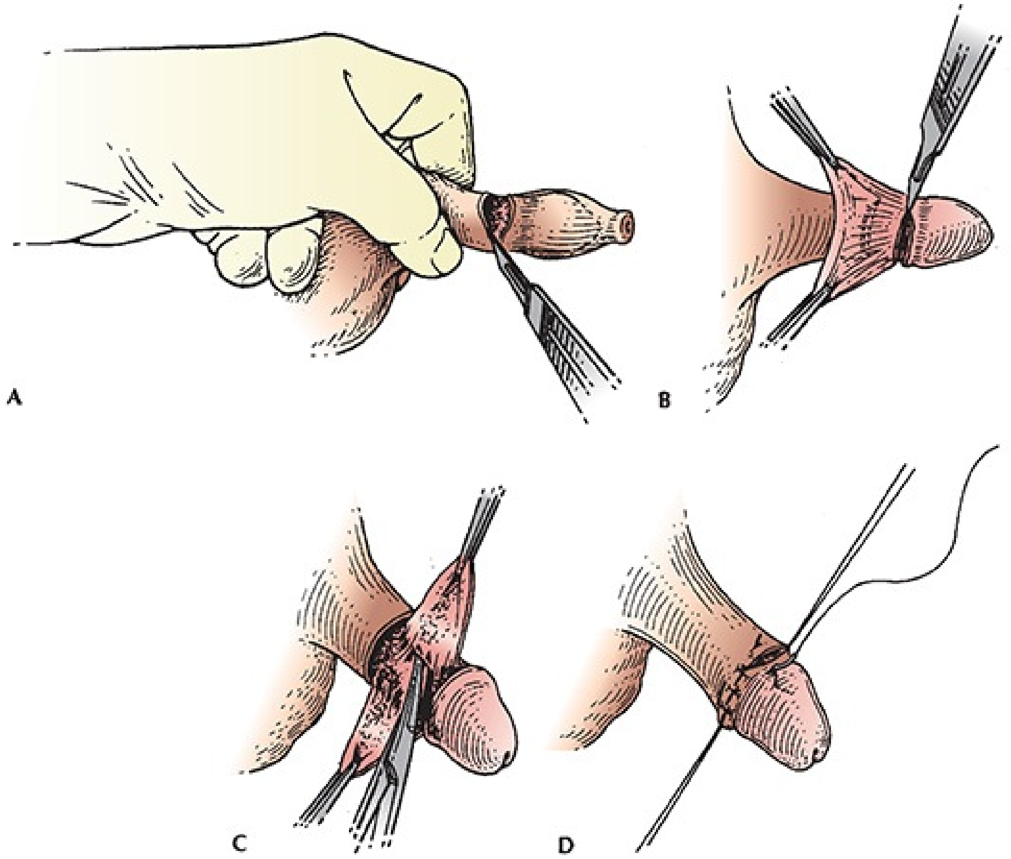

FIGURE 106.4 A: An incision is made on the shaft. B: A second incision is made below the coronal sulcus. C: Removing the excessive preputial skin. D: The wound edges are coapted and sutured together.

Alternatively, another circumcision method involves putting the prepuce on stretch after applying a hemostat to the dorsal and ventral aspects of the preputial orifice. The area of the shaft skin previously marked as overlying the coronal ridge is pulled forward beyond the tip of the glans and a straight clamp is applied, taking care to ensure that the glans is not included in the clamp. The prepuce distal to the clamp is amputated with a knife, the clamp is removed, hemostasis is secured, and the skin edges are coapted. It is especially important in this method to take down all preputial adhesions first or excess inner preputial skin may be left behind that may cause a tightening of the excess skin on the penile shaft, similar to paraphimosis in an uncircumcised male.

With the advent of synthetic tissue adhesives such as Dermabond (2-octyl cyanoacrylate, Ethicon), circumcisions can be performed quickly and safely with good cosmetic results in most children with minimal surgical time, few if any sutures required, and minimal tissue handling, thereby decreasing postsurgical swelling and possibly postsurgical pain (22) (Fig. 106.5).

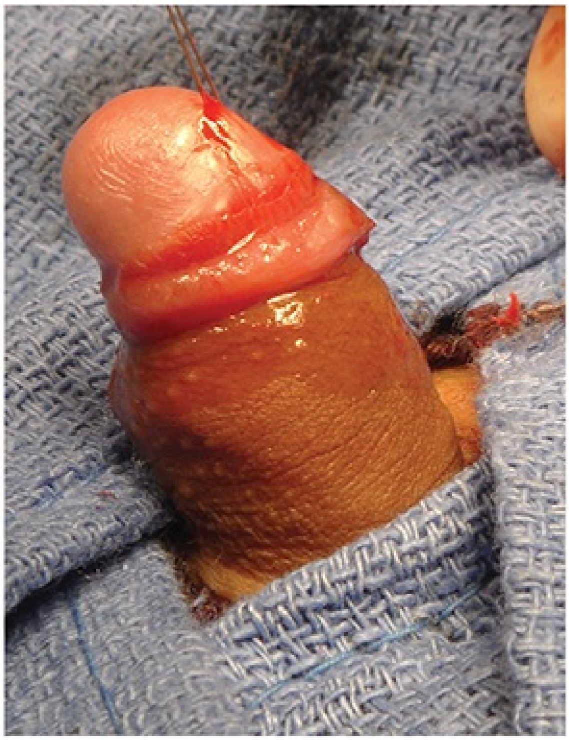

FIGURE 106.5 Photo of circumcision using 2-octyl-cyanoacrylate (Dermabond).

Neonatal Circumcision

In newborns, circumcisions performed without anesthesia previously were common. However, local anesthesia using an agent such as lidocaine or bupivacaine as a dorsal penile block or, more importantly, a ring block at the base of the penis can alleviate most of the pain experienced by the newborn at the time of the circumcision. The anesthetic dose must be adjusted for the weight of the patient.

In newborns, circumcision is in general accomplished using some type of device. The common devices in use in the United States are the Gomco clamp, the Plastibell, and the Mogen clamp. The methodology for the Gomco clamp and Plastibell is similar. After local anesthesia has been provided and the skin cleansed, the area of the coronal ridge is marked as previously described, followed by a dorsal slit being performed. Marking the outer shaft skin at the coronal ridge helps ensure that too much shaft skin is not removed during the circumcision. The Gomco device has three parts—a bell of variable size that fits over the glans, a plate, and a screw that completes the assembly. After the dorsal slit is performed and all the adhesions are released, the bell is then placed over the glans; a safety pin placed through the distal corners of the previously incised prepuce that keeps the edges aligned may be helpful. Then, the plate is placed over the glans, the shaft skin is pulled up until the marked area can be seen emerging from the hole in the plate, and then the screw is placed and tightened. The device is left in situ for several minutes and the prepuce distal to the plate is then excised with a knife. Electrocautery must never be applied to the Gomco device, as this has resulted in total necrosis of the penis. The device is then removed, reversing the order in which it was applied. By loosening the screw, the plate can be disengaged from the bell and removed. The cut skin edges of the penis are then gently teased over the edge of the bell to ultimately remove the bell and complete the circumcision; rarely are sutures needed for hemostasis for this type of clamp circumcision (Fig. 106.6).

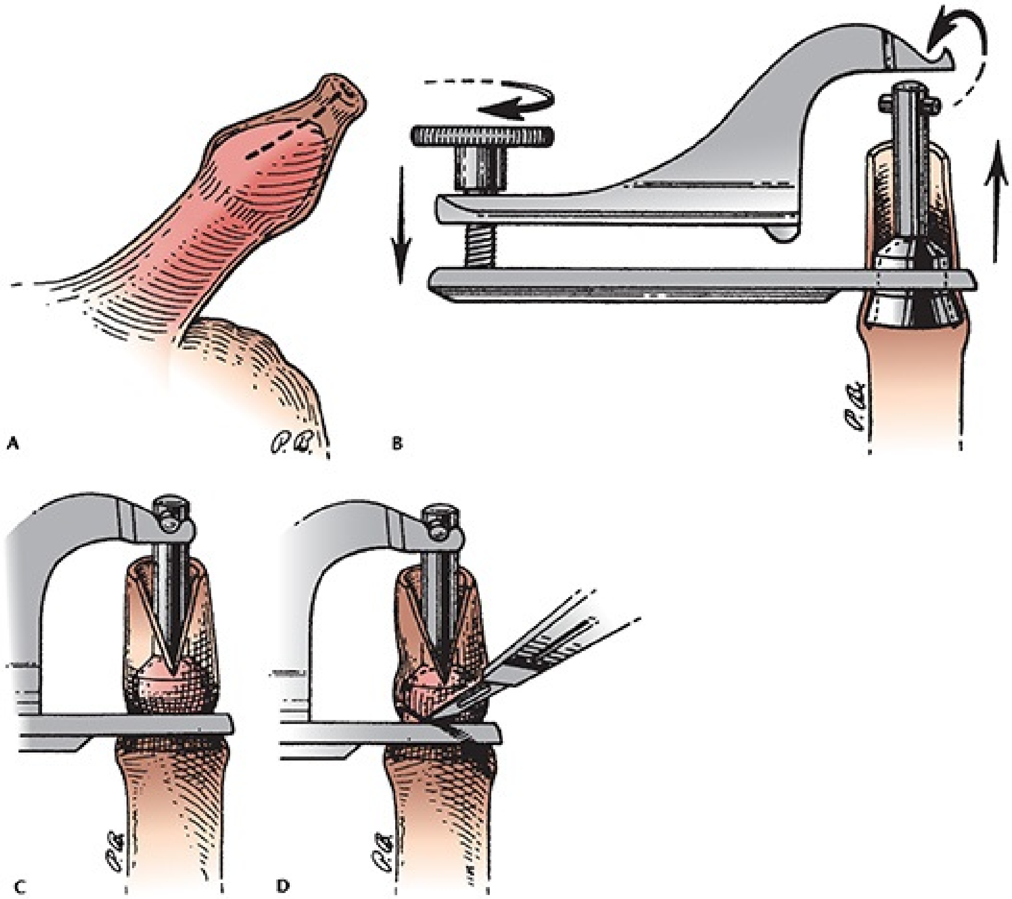

FIGURE 106.6 Gomco circumcision. A: Line of incision for dorsal slit. B and C: Application of the device. D: Excision of the prepuce.

The Plastibell follows the same principles as the Gomco device. After the bell is applied, a heavy string is tied over a groove at the base of the bell at the level of the previously marked area on the shaft. The distal prepuce is then excised. The stem distal to the bell is snapped off, leaving a plastic ring under the inner preputial epithelium. In roughly 1 week, the skin distal to the ligature sloughs and the ring comes off spontaneously (Fig. 106.7).

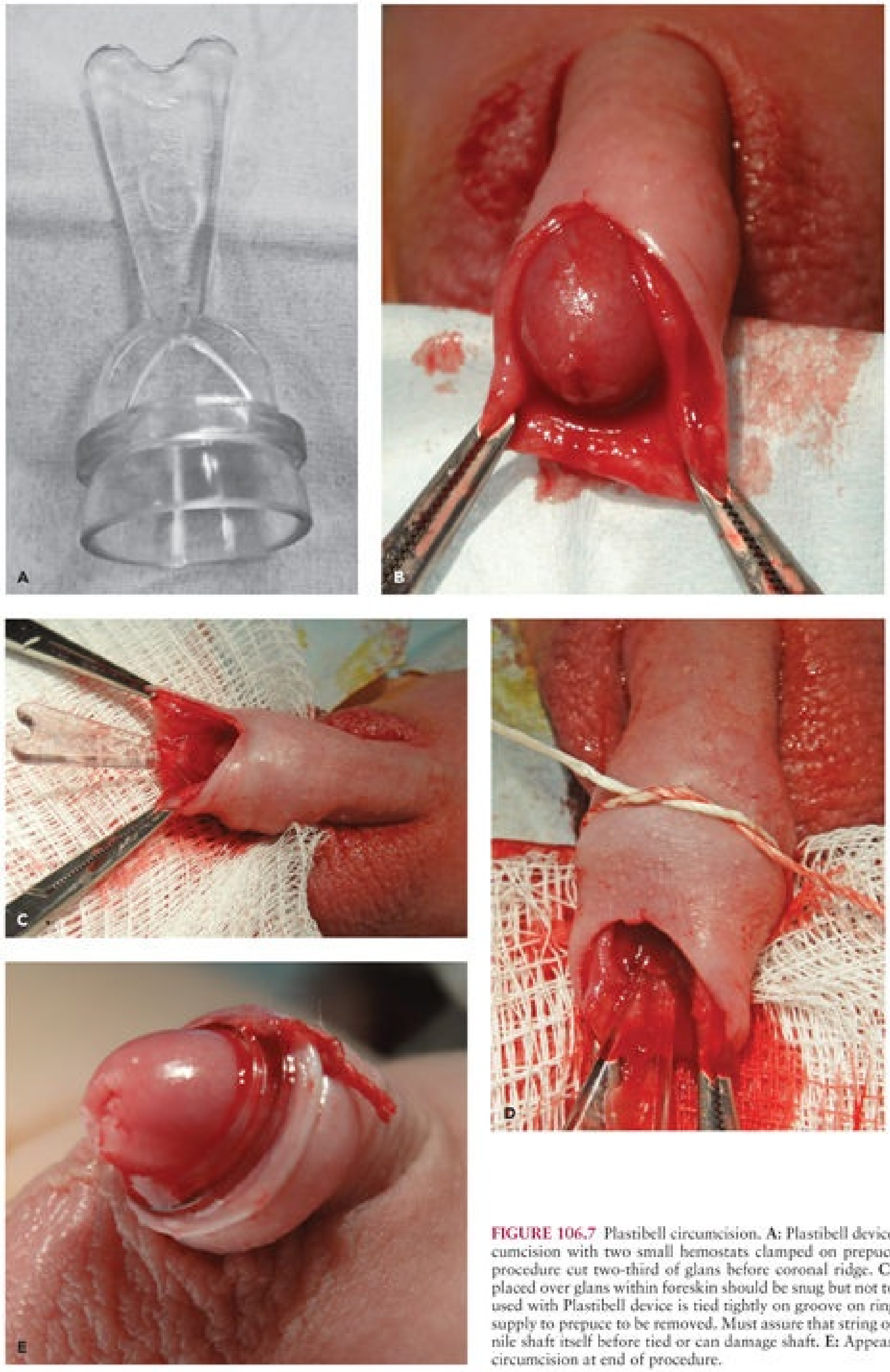

FIGURE 106.7 Plastibell circumcision. A: Plastibell device. B: Plastibell circumcision with two small hemostats clamped on prepuce after dorsal slit procedure cut two-third of glans before coronal ridge. C: Plastibell device placed over glans within foreskin should be snug but not too tight. D: String used with Plastibell device is tied tightly on groove on ring to cut off blood supply to prepuce to be removed. Must assure that string on ring and not penile shaft itself before tied or can damage shaft. E: Appearance of Plastibell circumcision at end of procedure.

The Mogen clamp is a clothespin-like device, and the methodology of its application is akin to the older open surgical method described previously. After the skin is cleansed and the area of the coronal ridge as seen through the shaft skin is marked with ink, the adhesions between the glans and the inner prepuce should then be lysed with a blunt probe. It is usually not necessary to perform a dorsal slit when using the Mogen clamp. The prepuce is pulled distally and the clamp applied, taking care to ensure that the glans is not included in the clamp. The clamp is closed and left in situ for a few moments. The prepuce distal to the clamp is excised and the clamp is removed. This type of clamp device is the easiest to use by those first performing neonatal clamp circumcisions, but it is the one most likely to have associated complications, typically partial or complete amputation of the glans if the glans is inadvertently enclosed in the clamp and cut when the tissue in the clamp is incised (23) (Fig. 106.8).

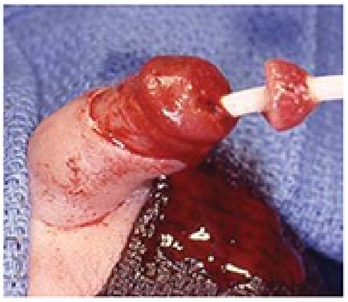

FIGURE 106.8 Traumatic amputation of portion of glans from Mogen clamp circumcision.

TIMING OF GENITAL SURGERY

Timing of the surgical repair of urogenital anomalies with a general or local anesthetic is important with regard to feasibility of the surgery, safety of the surgery to the patient, and the psychological impact of the anomaly and surgery. Penile surgery and repair of concealed penis or scrotal conditions can be scheduled at a time that is appropriate for the infant and convenient for parents and physicians, as these conditions or anomalies do not generally cause any functional detriment to the patient, with the exception of megaprepuce that may cause infections or voiding difficulties if not corrected. Technically, from the surgeon’s point of view, outpatient surgical correction with a general anesthetic may contemplated as early as the child’s fourth to sixth month, age adjusted for prematurity. Neonatal circumcision done with a local anesthetic may be performed in an office or nursery setting once the patient is clinically healthy, feeding well, and not known to have any bleeding or other problems that would preclude a circumcision in infancy.

Psychological aspects of surgery create a relative upper age time limit (24). The child’s anxiety concerning hospitalization, gender identity, separation from their parents and guardians, and subsequent sexual development generally increase with age as the child passes the age of 1 year. If genital surgery is performed before the child is 18 months of age, the patient will generally not remember the surgery nor associate the experience with any abnormality of his penis or scrotum. Therefore, optimal surgical timing for these patients is from generally best between 6 and 18 months. Parents need to determine what time during this window is best for their child and them. Most of these surgical repairs can usually be performed on an outpatient basis. Rarely will an overnight hospitalization be required. It is also easier for parents to care postoperatively for a boy who is younger and probably not ambulatory.

OUTCOMES

Complications

Occasionally, complications do occur, but most are minor and rarely portend a bad result. Bleeding is the most frequent complication and occurs in approximately 0.1% of cases. Most episodes of bleeding are minor and respond to pressure alone. Some require cautery or suture for control, particularly in the area of the frenulum. Most infections are minor and superficial, manifested by redness and occasionally purulence at the circumcision site that usually responds to local wound care. A common complication of neonatal circumcision is meatal stenosis, probably produced by a chemical meatitis from ammoniacal urine exposure on the tip of the penis while the patient is still wearing diapers. Serious complications, fortunately, are rare but include recurrent phimosis, wound separation, major tissue loss, concealed penis, skin bridges between the shaft and the glans, inclusion cysts, urethrocutaneous fistula, and loss of some of the glans or all of the penis as an extremely rare occurrence.

Necrotizing fasciitis, also termed as *Fournier syndrome* or *gangrene*, has occurred in infants and young children after circumcision as well as after other injuries and secondary infections to the perineum (25,26). Several cases of necrotizing fasciitis after newborn circumcision have been reported with at least two of the patients' having a circumcision using a Plastibell device (25). It is imperative that infants who develop edema and erythema of the scrotum and lower abdomen be evaluated and treated aggressively surgically and medically to prevent more serious sequelae of the process. The patient may or may not have a fever on initial presentation. Infection after newborn circumcision is not very common, but it is more common where a Plastibell device is used as compared to the other clamp devices that are used (Fig. 106.9).

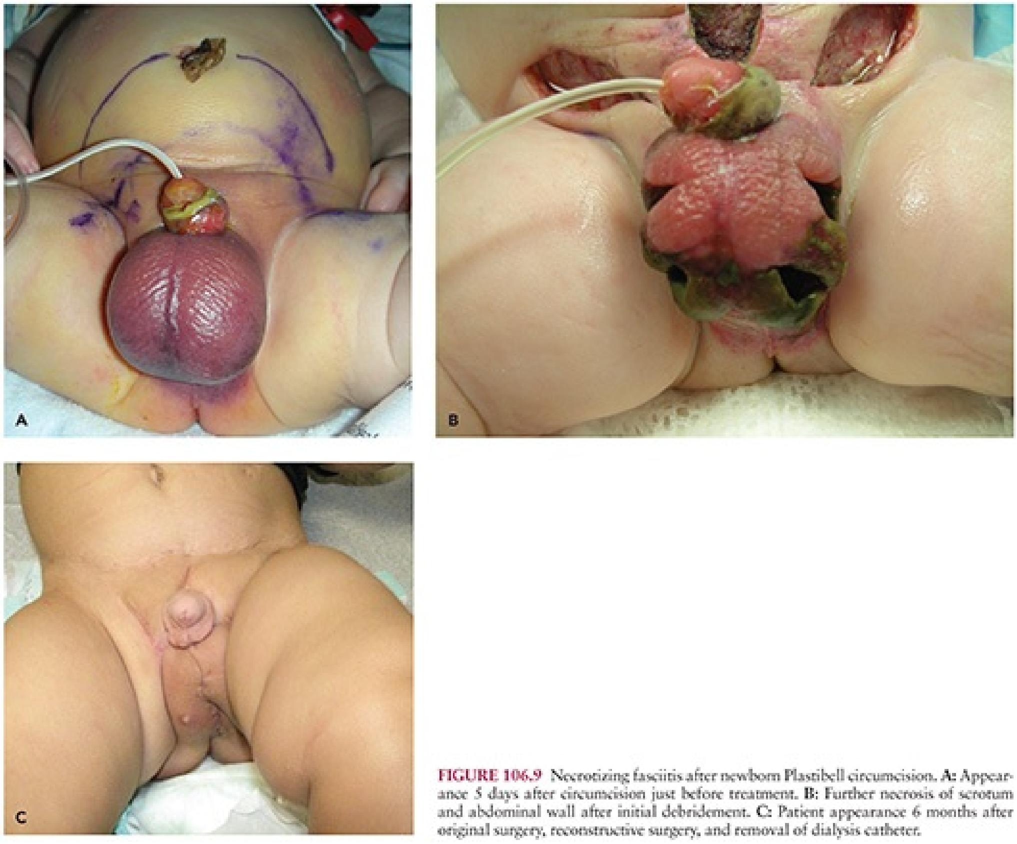

FIGURE 106.9 Necrotizing fasciitis after newborn Plastibell circumcision. **A:** Appearance 5 days after circumcision just before treatment. **B:** Further necrosis of scrotum and abdominal wall after initial debridement. **C:** Patient appearance 6 months after original surgery, reconstructive surgery, and removal of dialysis catheter.

Results

A circumcision should remove a sufficient amount of the prepuce so that the glans is exposed, significantly reducing the risk of developing phimosis, paraphimosis, BXO, or balanoposthitis.

CONCEALED PENIS (MEGAPREPUCE)

Congenital megaprepuce or concealed penis is a relatively recently described condition where the inner prepuce is excessively redundant and accompanied by a relative paucity of outer penile shaft skin with scrotalization of the penile shaft. Since its initial description in 1994 (27), it has been found more frequently. These children should *not* have a typical newborn circumcision performed as that will primarily remove penile shaft skin, not address the excessive inner preputial skin, and result in a more concealed or buried penis with resultant loss of penile shaft skin necessary for a normal circumcised penis appearance. The etiology of this condition is not well defined but described as either failure of the urethral folds and scrotal folds to separate, failure of the penis to develop its normal attachments to the pubic region, or infolding of the prepuce causing outlet obstruction and dilation of the inner prepuce (28,29).

Since the first reports of this condition, many authors have described their preferred surgical corrective procedure (28–31). All authors agree that this condition does require surgical repair because the inner prepuce will continue to dilate and produce increasing urine pooling in the redundant sac surrounding the penis causing urinary tract infections, treatment-resistant perineal rashes, and incomplete voiding necessitating manual drainage of the urine from the preputial sac by the child’s caregivers (Fig. 106.10).

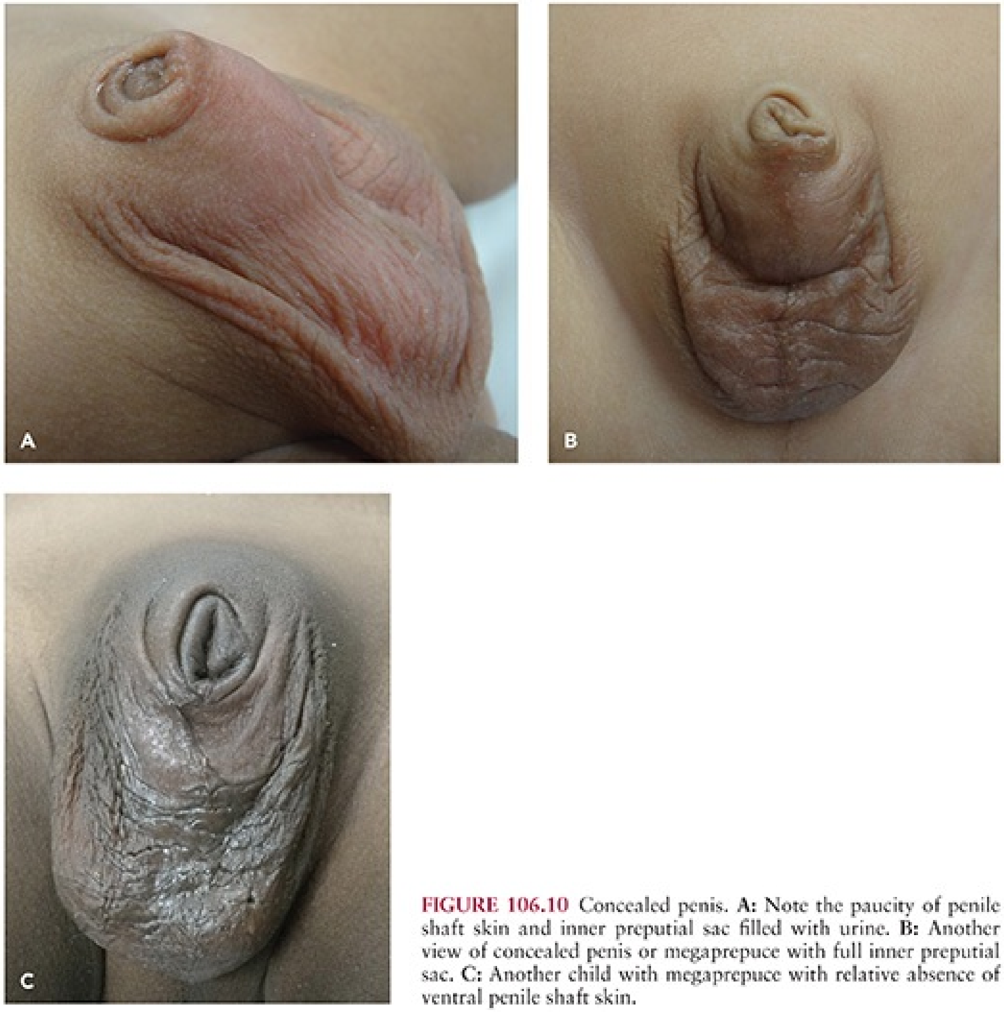

FIGURE 106.10 Concealed penis. **A:** Note the paucity of penile shaft skin and inner preputial sac filled with urine. **B:** Another view of concealed penis or megaprepuce with full inner preputial sac. **C:** Another child with megaprepuce with relative absence of ventral penile shaft skin.

All of the procedures try to use the redundant inner preputial skin because it provides good coverage of the shaft, relieves the inner preputial reservoir of urine, and provides a cosmetically acceptable circumcision appearance.

Two preferred methods use this inner preputial skin differently: one as primary coverage of the penile shaft (30,31) and the other as accessory coverage, if needed (28,29).

Repairs using the inner skin as primary coverage start with circumferentially elliptically incising the skin at the preputial penile shaft skin junction (31) or excising the preputial phimotic ring itself (30). The inner preputial skin is then unfurled and attached to the previously cut skin edge, which is located at the penoscrotal junction after the incision or excision of the phimotic band is made. The excess inner skin is reduced and removed to allow adequate coverage of the shaft itself. The scrotum in this technique drops down to its normal location at the base of the penile shaft after the initial stage of the procedure. Absorbable sutures are used for the repair. A temporary urethral tube may be left to drain the bladder but generally is not necessary. A pressure dressing can also be used as is used with hypospadias surgery to reduce postsurgical edema at the discretion of the performing surgeon but is not necessary.

Alternatively, the inner preputial skin can be used as additional skin coverage and not primary coverage. In these techniques, the initial incision originates on the scrotum itself, generally at the location where the outer bulge of the ballooned megaprepuce meets the scrotum. The skin is incised down to the penoscrotal junction and the inner preputial skin is then unfurled or degloved from this ventral scrotal incision. The inner preputial skin is then incised to form a coronal cuff as left on a routine circumcision. These approaches differ in that the penile shaft coverage here is from the penoscrotal skin giving thicker skin coverage typical to normal penile shaft skin than the thinner inner preputial skin. The excess inner preputial skin may be used to fill in any ventral skin deficit that may occur, but the dorsal skin coverage is more consistent to the penile shaft skin that is seen after routine circumcision. The scrotal skin flaps are then rotated to meet in the midline using absorbable sutures to create a normal penoscrotal junction appearance. The dressing placed may be a pressure dressing or not as preferred by the operating surgeon. Bladder drainage may be used but is also not necessary for this technique (Fig. 106.11).

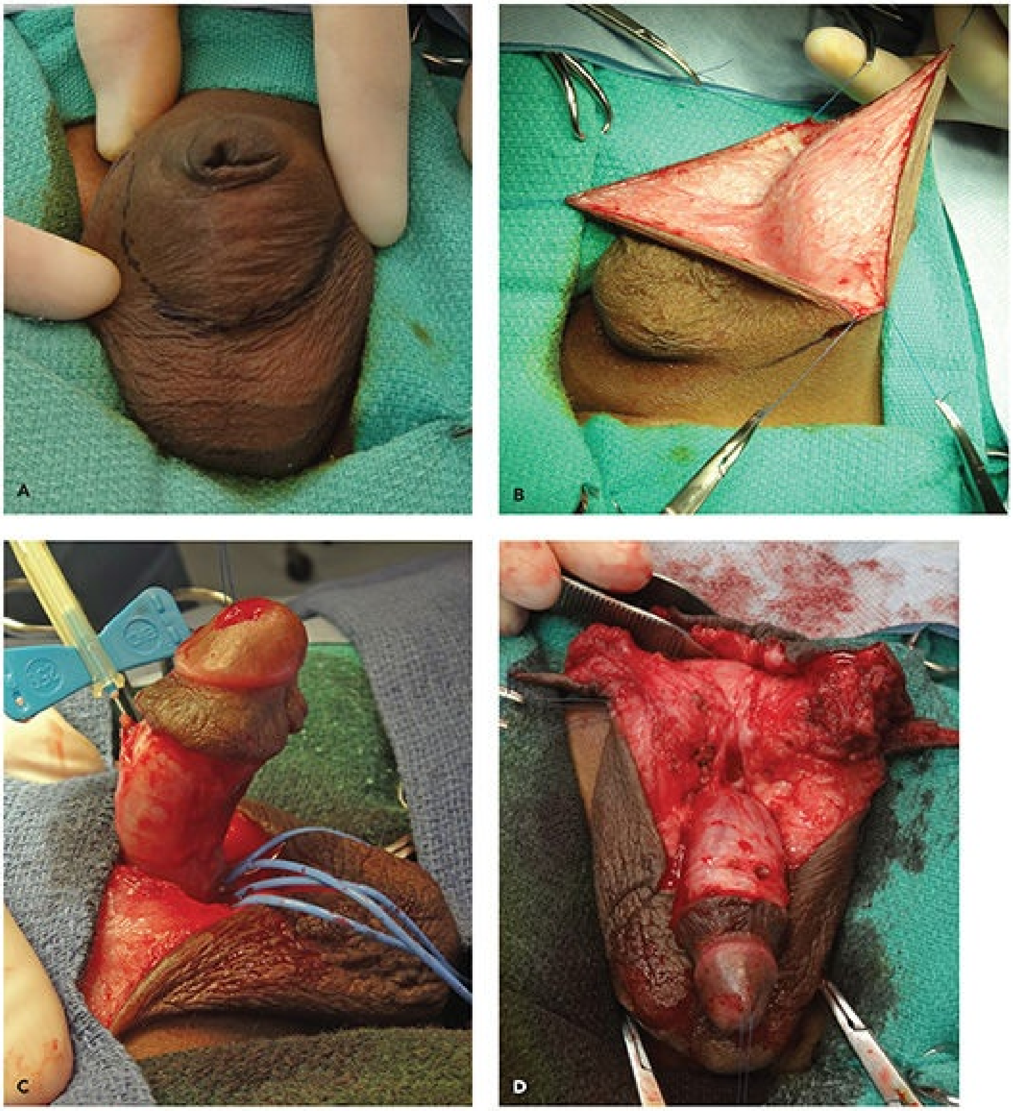

FIGURE 106.11 Concealed penis repair. **A:** Initial step is to mark the extent of the inner preputial sac on scrotum. **B:** Penoscrotal mark is incised, and penis is degloved from ventral incisional area. **C:** Artificial erection shows mild ventral chordee which was corrected. Scrotal flaps will be rotated medially to place scrotum in normal position. **D:** Inner preputial skin and shaft skin rotated on superior to the penile shaft and will be rotated to cover the dorsal shaft. Residual inner preputial skin will be used to cover areas on the ventral shaft requiring skin coverage. (*continued*)

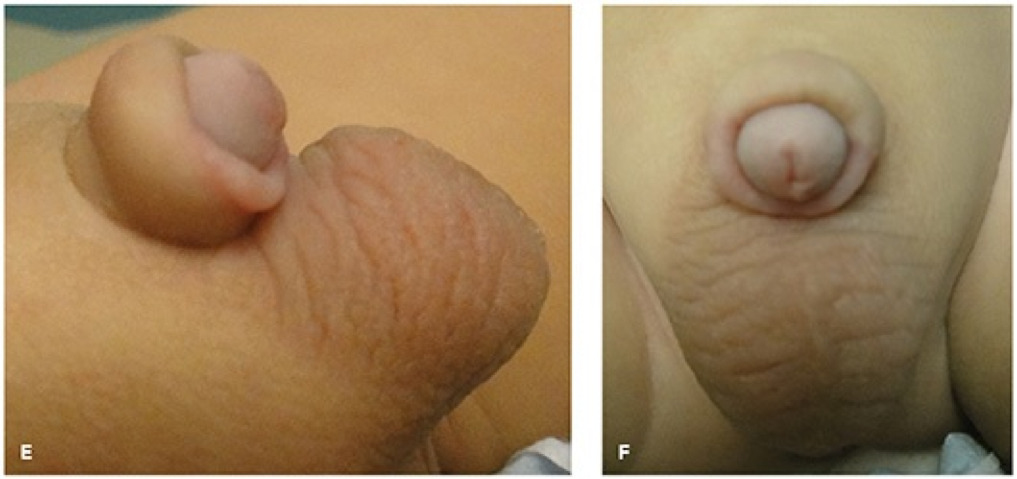

FIGURE 106.11 *(continued)* **E:** Postsurgical results on a different patient 6 months after megaprepuce repair. **F:** Postsurgical results on same patient as previously 6 months after repair.

It may be reasonable to perform an artificial erection to evaluate for possible chordee because there has been an association of ventral chordee with megaprepuce in some patients (Fig. 106.12).

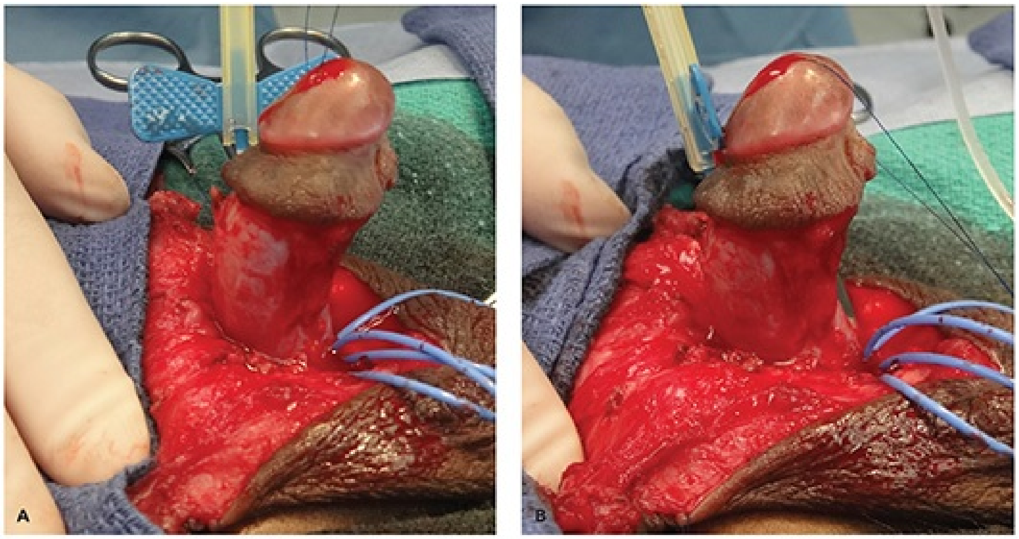

FIGURE 106.12 Chordee associated with concealed penis. **A:** Ventral chordee found with artificial erection test after inner preputial skin degloved. **B:** Penis straightened with dorsal plication before finishing the scrotoplasty and penile shaft skin coverage.

All sutures used in any of these techniques are absorbable, at the preference of the operating surgeon, similar to those used for circumcision and scrotal surgeries.

Outcomes

Complications

Reported complications have been few. Rarely, scar tissue may form at the penoscrotal junction causing some tethering of the penis with healing. Those techniques using the inner prepuce at complete shaft skin coverage may have some redundancy but generally do not need reoperation. Bleeding and infection complications, although not reported in these series, would be similar to expected occurrence with routine circumcision.

Results

Concealed penis or megaprepuce is a relatively new indication for surgical repair. Resolution of the inner preputial sac occurs with all procedures described. Cosmetic results vary with the technique used but are generally acceptable with any technique used. The only difference is the shaft skin coverage with the initial scrotal approach tends to be thicker shaft skin as seen with a typical circumcision as compared to the shaft coverage when using the thinner inner preputial skin alone. Penile curvature may be present in some children who should have this evaluated and treated if found.

CONGENITAL ANOMALIES OF THE SCROTUM

Isolated congenital anomalies of the scrotum, including inclusion cysts, the bifid or hypoplastic scrotum, penoscrotal transposition, and webbed penis, scrotal ectopia, agenesis, or accessory scrotum, are uncommon. Generally, these anomalies are associated with other genitourinary abnormalities such as penoscrotal transposition and bifid scrotum with hypospadias, bifid scrotum and scrotal ectopia seen with exstrophy, scrotalization of the penile shaft skin in megaprepuce, and scrotal hypoplasia associated with cryptorchidism. Isolated scrotal anomalies are sometimes associated with other congenital malformations, such as hemangiomata, cardiac, cerebrovascular, ocular, and sternal defects (32). Children presenting with these isolated scrotal conditions (scrotal agenesis, hemiscrotal agenesis, ectopic or accessory scrota) should be evaluated for nongenital-associated congenital conditions. When scrotal anomalies occur in conjunction with other genital abnormalities, the scrotum can generally be surgically repaired, with excellent results, at the same time of surgical correction of the associated genital condition (Fig. 106.13). Neonatal circumcision must not be performed in boys with genital anomalies because the prepuce may be required for reconstruction of the penis and scrotum, especially if there is scrotal agenesis or megaprepuce. The prepuce is an excellent tissue graft source where scrotal or penile skin would otherwise be insufficient to correct these genital conditions. Megaprepuce or concealed penis, as previously described, combines abnormal scrotal and preputial development. Surgical repair of this condition involves combining penile as well as scrotal surgical techniques (28–30,33).

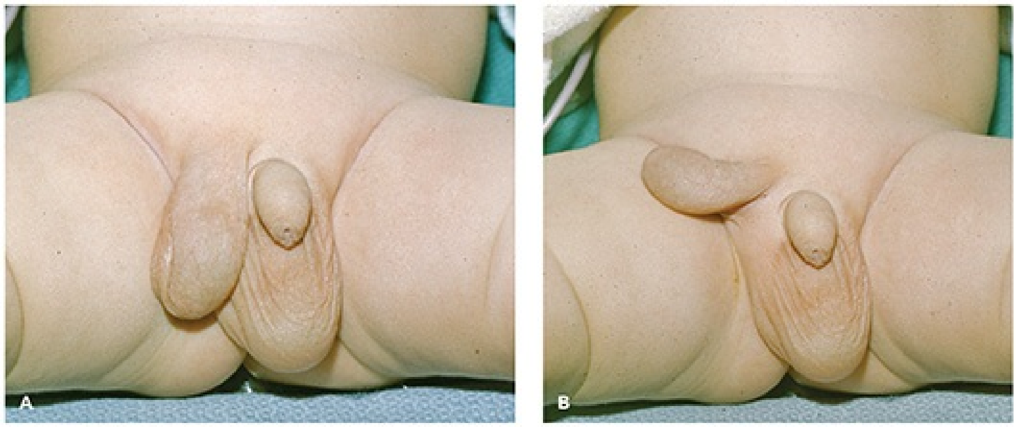

FIGURE 106.13 Ectopic scrotum. **A:** Young boy with ectopic right scrotum with testis in sac before correction. **B:** Another view of ectopic scrotum in same patient.

Diagnosis

The diagnosis of scrotal congenital anomalies is made by physical examination. Because it is rare for these anomalies to occur alone, the patient should be appropriately evaluated for associated anomalies, both genital and systemic. The physician should examine the scrotum for its relative position to the penis, rectum, and median raphe. The scrotal appearance should be examined with attention to symmetry and the general anatomy of the patient to find the associated conditions (bladder exstrophy, hypospadias, cryptorchidism, cardiac, hemangiomata cerebrovascular, ocular, and other linked findings). Specifically, the testes, penis, urethra, and rectum should be inspected to ensure that they are normal.

Indications for Surgery

Timing of the surgical repair of urogenital anomalies is important with regard to feasibility of the surgery, safety of the surgery to the patient, and the psychological impact of the anomaly and surgery. The use of optical magnification and fine absorbable sutures applies to scrotal procedures as well as penile surgeries with optical magnification not always required for some simpler scrotal procedures.

The use of tissue expanders for progressive skin dilatation, as in the cases of hypoplastic or absent scrotum, has offered a viable alternative to myocutaneous flaps, which often result in a poor cosmetic result in the pediatric population. Again, prophylactic antibiotics are seldom necessary in uncomplicated cases with the prepubertal child that do not involve instrumentation of the urinary tract.

Alternative Therapy

There are no alternatives to surgical correction for these congenital anomalies. However, nontreatment is an option, or reconstructive surgery can be delayed until the boy can participate in the decision to proceed. The psychological advantage of earlier surgery would need to be weighed against the importance of allowing the youngster to be involved in the decision-making process.

Surgical Technique

Bifid Scrotum

Isolated bifid scrotum is rare. Most patients who present with a bifid scrotum will have associated hypospadias and chordee. When it occurs in isolation, the corpus spongiosum appears to be continuous with a prominent median raphe of the scrotum, a fibrous band that separates and divides the scrotum into two individual parts. Surgical reapproximation of the two hemiscrota can be achieved after dissection and excision of this midline band. The underlying urethra must be preserved and allowed to fall away from the dense band. Mobilization of each hemiscrotum is required to the extent that each hemiscrotum can be elevated and moved medially to the midline. Closure is accomplished using two layers. Deep absorbable sutures allow fixation and reconstruction of the midline. Surgical fixation of the testes is rarely necessary unless there is associated cryptorchidism. Fine absorbable sutures should be used to close the skin. In general, interrupted simple sutures are used, but a running subcuticular closure or horizontal or vertical mattress sutures may also be used at the preference of the surgeon.

Penoscrotal Transposition

Various degrees of penoscrotal transposition exist, ranging from the complete form (34,35), in which the scrotum is actually anterior and cephalad to the base of the penis, to incomplete forms, in which the penis emerges from the center of the scrotum, and milder forms, in which only the superior edges of the scrotum lie anterior to the penis. As with other anomalies of scrotal formation, there may be some associated congenital anomalies such as imperforate anus, chromosomal, vertebral, and central nervous system anomalies (36). For correction of the anomaly, the two hemiscrota are mobilized, swept inferiorly and medially, mimicking the normal embryologic migration of the labioscrotal folds, and sutured together. It may be necessary to transpose the penis cephalad to the scrotum. This can be achieved by using a skin bridge (Fig. 106.14) or by dividing the abnormal scrotum in its midline cephalad and caudal to the phallus and swinging both halves below the penis (Fig. 106.15) or using a scrotal mobilization technique as in megaprepuce repair (28–30,33). Some authors suggest leaving a segment of skin intact cephalad to the penis to avoid jeopardizing the vascularity and lymphatic drainage of the penile shaft skin. Other authors advocate the creation of a suprapubic buttonhole through which the penis can be delivered (37–39). For less severe cases of penoscrotal transposition, the wedge of ectopic scrotal skin is removed and the resultant defect closed, thereby eliminating the problem (40). This approach is most appropriate when there is incomplete mild penoscrotal transposition. The penoscrotal angle can be recreated by anchoring sutures applied to the underlying fascia and corresponding skin but is not always necessary, especially if the scrotal repair is primarily ventrally performed (28–30,33). Fixation of the penopubic angle can also be performed in a similar fashion. The anchoring sutures may have the additional benefit of stabilizing penile length (33,41).

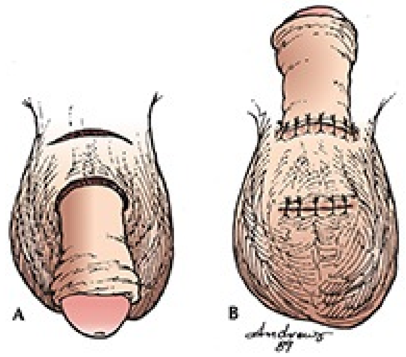

FIGURE 106.14 **A:** In the moderately severe case of penoscrotal transposition, the phallus is circumscribed and freed of supporting tissue. An incision is made cephalad to the base of the phallus. **B:** The penis can then be brought back through the new opening and the skin sutured about it. The original opening is then sewn closed.

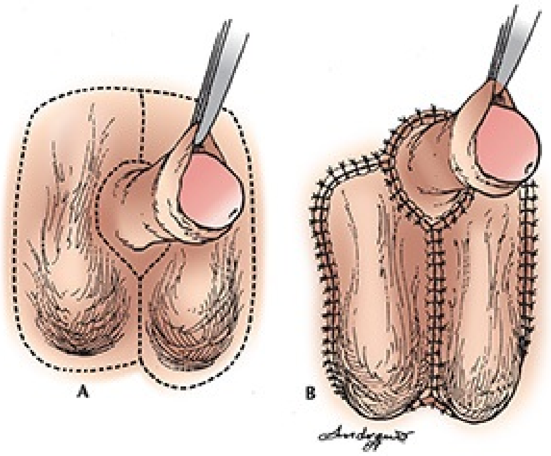

FIGURE 106.15 **A:** In the more severe case of penoscrotal transposition, each hemiscrotum is circumscribed. **B:** Once each side is freed to rotate caudally and medially, the two portions are sewn together. Some authors suggest leaving a bridge of skin cephalad to decrease the possibility of a vascular insult.

Scrotal Hypoplasia

Scrotal hypoplasia is generally only seen in boys with cryptorchidism. A small tight muscular scrotum where both testes are descended is not hypoplastic and does not require any surgical intervention. Surgical intervention is not needed for the hypoplastic scrotum with or without associated cryptorchidism. Orchiopexy can easily be performed in this group without tissue expanders or testosterone treatments prior to surgery. There may be a limited role for androgen stimulation in testis prosthesis placement in a hypoplastic scrotum using either testosterone enanthate, 2 mg per kg intramuscularly, or testosterone cypionate, Depo-Testosterone, 25 mg intramuscularly once a month for up to 3 months, as is done for complex hypospadias repair as a similar treatment plan to help with scrotal development prior to prosthesis placement. This short-term testosterone program will induce scrotal development and enlargement in addition to increasing penile length and glans circumference (42). This allows easier surgical placement of prosthesis in the poorly developed scrotum at the time of surgery. The hormonal treatment effects are temporary so the proposed surgical procedure should be done shortly after finishing the testosterone course to get the benefits of the scrotal enlargement. In severe cases of scrotal hypoplasia or the rare case of congenital scrotal agenesis, tissue expanders may be used as another alternative where there is inadequate space for the testis or prosthesis. The preoperative use of testosterone in patients with scrotal hypoplasia is rarely indicated, however, and should only be used if the placement of a testicular prosthesis is contemplated and the scrotum is extremely hypoplastic and may not accept the prosthetic when placed. The expanders can be used to progressively dilate the scrotum to an adequate size.

Placement of a testicular prosthesis before puberty is not routinely advocated because these children will outgrow an initial small-sized prosthesis and need to have the smaller prosthesis changed out to a larger size at a later date. However, in patients with bilateral anorchia, either due to perinatal testis torsion of both testes or both testes never forming, it may be reasonable to place appropriately sized testis prostheses in this group at a young age. Families are devastated by the absence of both testes in their child, especially with the long-term ramifications that their child will need lifelong hormone supplementation and is infertile from birth. Having prostheses placed alleviates some of this devastation, as the child will look “normal” to the family by having a full scrotum. Additionally, these prostheses will act as tissue expanders for when larger prostheses are placed in adolescence.

Scrotal Ectopia and Accessory Scrotum

Although less common than either scrotal transposition or a bifid scrotum and usually associated with cloacal exstrophy, scrotal ectopia on occasion is found in the otherwise normal child (43). Ectopia is generally thought to be due to the abnormal migration of the labioscrotal folds during embryologic development, whereas accessory scrotum may be due to intervening tissue disrupting the normal migration of the folds. These children need to be evaluated for other congenital conditions because they frequently will have associated ipsilateral renal agenesis or dysplasia. There may also be an association with imperforate anus (44). The ectopic scrotal tissue can be found on the inner aspect of the thigh or caudal and inferior to the external inguinal ring (Fig. 106.5). Often, the ipsilateral testis can be found within the ectopic tissue as an undescended testis. Correction is accomplished by relocating the ectopic tissue, by way of a flap or graft, or by utilizing the normally positioned contralateral hemiscrotum as a reservoir for both gonads and discarding the ectopic tissue, depending on the size and location of the ectopic scrotum (16). Again, rarely does treatment of scrotal ectopic require tissue expanders or androgen hormone pretreatment. If needed, a short course of testosterone injections (testosterone enanthate 2 mg per kg intramuscularly or Depo-Testosterone [testosterone cypionate] 25 mg intramuscularly for three doses given monthly) may increase the size of the truly hypoplastic ectopic scrotum, or primary stretching of the ectopic tissue may allow the scrotal tissue to be expanded for orchiopexy and reconstruction of the scrotum itself.

Accessory scrotal tissue, generally found in the perineum, is also a rare condition. In distinction with scrotal ectopia, these accessory folds are not associated with cryptorchidism, ipsilateral renal agenesis, or abnormal scrotal median raphe anatomy. These folds may be part of the popliteal pterygium syndrome (45). There may be an underlying lipoma. Surgical excision of the accessory scrotal tissue and lipoma is usually all that is required (Fig. 106.16A–C). Generally, these rare accessory scrotal sacs are removed due to abnormal cosmesis and due to irritation and inflammation of the sac in an abnormal perineal position (44).

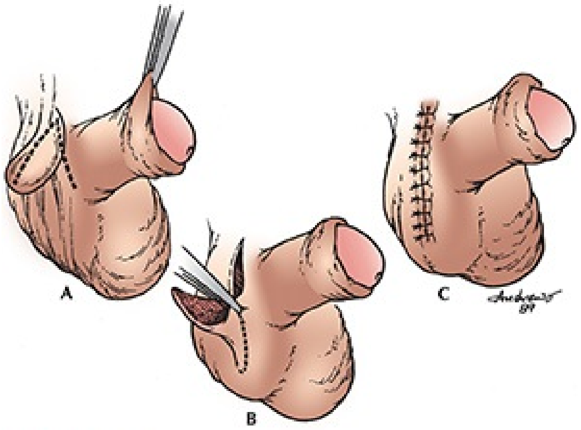

FIGURE 106.16 **A and B:** In the case of mild scrotal ectopia, a wedge of ectopic scrotal skin is excised. **C:** The defect is then closed, thereby eliminating the ectopic scrotal skin.

Scrotal or Hemiscrotal Agenesis

Scrotal agenesis is an extremely rare condition with only six cases being reported in recent literature (32). These boys are missing the entire scrotal tissue mass from the base of the penis to the anus. All patients have a male karyotype (46). Testes are generally present but in either an undescended or ectopic location. The penis and other external androgen-dependent structures are typically normal. Testis location may be palpable in the inguinal or ectopic positions, or the testes may be nonpalpable and intra-abdominal in location.

Scrotal agenesis has been associated with other congenital anomalies, specifically, facial anomalies, developmental delay, nystagmus, and cardiac defects. Importantly, as the patient presents with an elongated male phenotypic phallus, it is imperative to ascertain that some disorder of sexual differentiation is not present, given the male phenotypic appearance with an absent scrotum. A karyotype must be performed, and the child must be evaluated for congenital adrenal hyperplasia. Determination of the cause of scrotal agenesis rests on possible localized 5-alpha reductase deficiency or receptor deficiency or malformation. Alternatively, there may just be failure of the labioscrotal folds to form.

Hemiscrotal agenesis is an even rarer phenomenon, with only two cases reported to date (32,47). These boys may also need to be evaluated for possible congenital adrenal hyperplasia. Interestingly, these boys have what appears to be a normally developed hemiscrotum with a normal median raphe. Both testes, in the cases reported, were descended in the normal scrotal sac and in the normal location of the side without a scrotal sac. These patients may also have some associated congenital conditions, including ocular, cardiac, cerebrovascular, hemangiomata, and sternal defects, whereas one of the reported patients had no such associated conditions.

Surgical construction of scrotal sacs in scrotal agenesis may be done by various techniques, but the most common and most anatomically based requires using the preputial skin as a replacement for the scrotal skin. These children *must not* be circumcised. The initial surgery involves incising the inner prepuce circumferentially near the coronal ridge and then unfolding the prepuce and degloving the penis, so that a long tube of skin is created. This tube is then split ventrally along the midline down to the perineal raphe region. Buttonholing the dorsal flap surface allows the previously distally located preputial skin to be rotated as flap over the glans and into the perineum as a scrotal sac.

Generally, tissue expanders or testis prostheses are placed in the newly created scrotal sacs and delayed orchiopexies are planned for several months after the first procedure (46,47).

Hemiscrotal agenesis typically does not require such extensive reconstructive procedures as does complete scrotal agenesis. Orchiopexy of the ipsilateral testis with hemiscrotal agenesis may be performed by placing it in the developed hemiscrotum. Alternatively, a similar hemiscrotal construction may be contemplated as is described for complete scrotal agenesis but is rarely needed (32,48).

Webbed Penis

In boys with a webbed penis, scrotal skin is tethered to the ventrum of the penile shaft. This tethering produces a web of skin stretching from the penis to the scrotal base (Fig. 106.17A). The webbed penis causes no problem during childhood unless there is significant tethering of the penis from a scrotal web that is located high on the penile shaft. This can causes difficulties with toilet training and with transitioning to standing to void in some boys due to the tethering high on the shaft. Also because the scrotal skin is hair-bearing, future intercourse could be difficult or uncomfortable with the scrotal webbed skin on the shaft of the penis (Fig. 106.17B and C). Therefore, a webbed penis is usually corrected during infancy or prior to the child being ambulatory. A modified circumcision can often correct minor webbed defects. The circumcision incision can be brought more distally than normal on the ventrum to repair short defects, thereby preserving all penile shaft skin possible in that location. After the inner preputial skin is excised, the additional length on the ventrum allows the scrotum to fall away from the glans and penis. Inner preputial skin can also be unrolled, if necessary to help drop the scrotal web further down to the normal penoscrotal junction area, if the web is very distal on the shaft. If necessary, skin from the dorsum can be mobilized and swept ventrally to provide additional shaft skin. A second type of repair can be performed by incising the web transversely and closing it longitudinally, thereby separating the penis from the median raphe of the scrotum. Care should be taken not to make this mobilization too limited as a cicatrix may occur after the Heineke-Mikulicz closure. Circumcision is usually performed at the same time because it facilitates the approximation of the skin (Fig. 106.18).

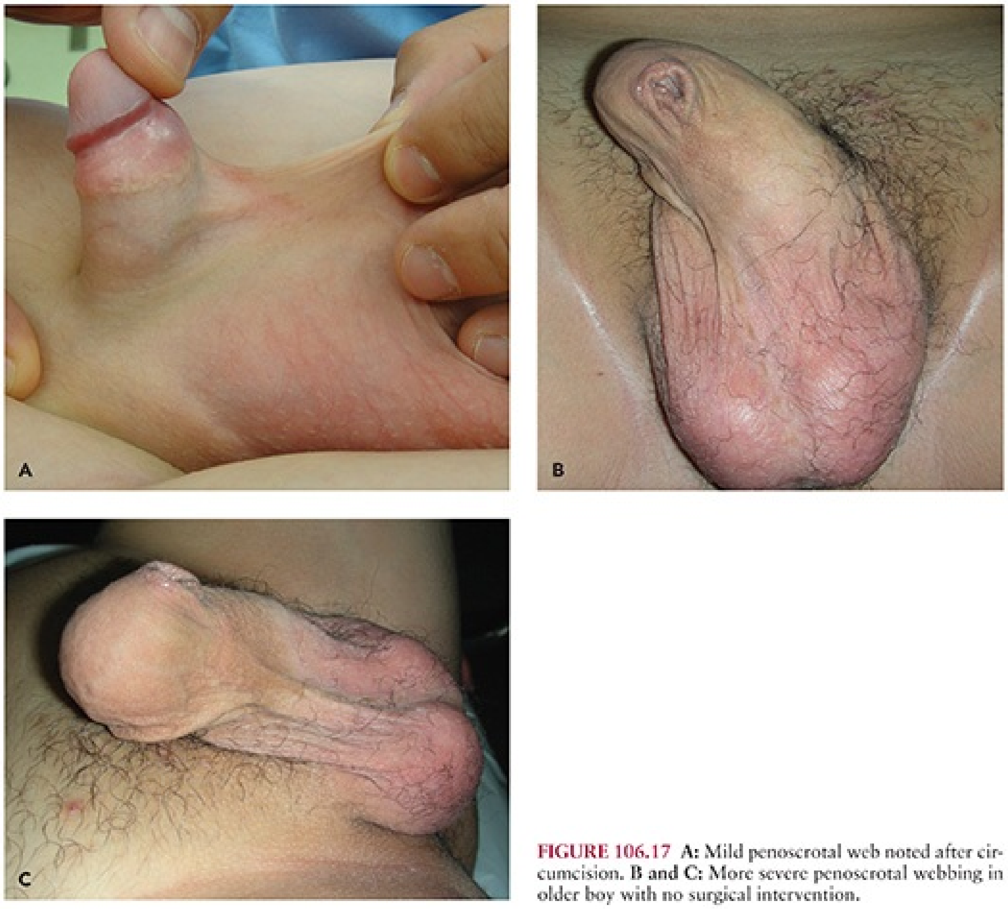

FIGURE 106.17 **A:** Mild penoscrotal web noted after circumcision. **B and C:** More severe penoscrotal webbing in older boy with no surgical intervention.

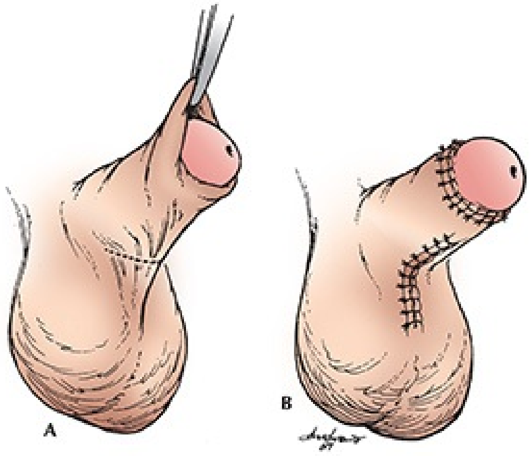

FIGURE 106.18 In the moderately webbed penis, the defect can be repaired by transversely incising the web (**A**) and closing it longitudinally (**B**). As in the mild cases, a modified circumcision incision with preservation of all the ventral skin can be helpful in recovering the penile shaft.

In more severe cases of webbed penis, a U-shaped incision is made about the phallus (49). This releases the penis from the dependent scrotum. Flaps are developed to allow ventral closure of the penis with fine absorbable sutures. The scrotum is closed in a side-to-side manner (Fig. 106.19). In a manner similar to cases of penoscrotal transposition, the penoscrotal angle can be recreated by the placement of anchoring sutures securing the skin to the underlying fascia, although rarely is this needed.

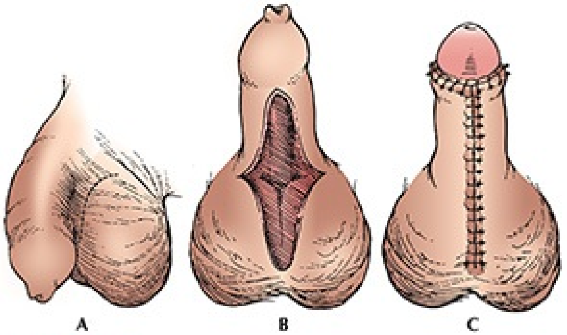

FIGURE 106.19 **A:** In a severely webbed penis, an incision is made between the penis and scrotum. **B:** Skin flaps are elevated in all directions so that the surgical defect can be closed. **C:** A two-layer closure is used to stabilize and approximate the skin and underlying tissues.

Scrotal Inclusion Cysts

Midline scrotal inclusion cysts are uncommon but benign and dermatoid in origin and can be managed by local excision (49). They may occur anywhere in the midline from the external urethral meatus to the anus. They occur as an aberration of the normal embryologic development of the male genital fusion of the urethral folds enveloping the urethral groove. However, care must be taken not to confuse these cysts, especially those situated near the anus, with a sinus associated with an imperforate anus or anal fistula. A fistula from imperforate anus can rarely track anteriorly to the penoscrotal junction. All of these cysts can be found ventrally as is the commonly found urethral meatal cyst. All are located in the median raphe, and these cysts can be multiple (Fig. 106.20). Most inclusion cysts are found because of cosmetic disfigurement, but these cysts can get infected or have calculus formation making it reasonable to consider excision of the inclusion tracts with care to evaluate anal components prior to surgical excision (49,50).

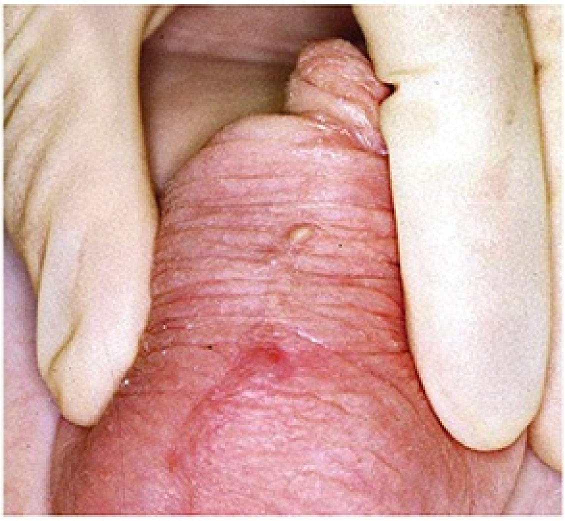

FIGURE 106.20 Median raphe scrotal inclusion cysts.

Outcomes

Complications

Complications from these surgeries are in general uncommon. Superficial infections can be treated with antibiotics.

Results

The cosmetic results of this surgery are usually excellent. It is imperative, however, in many of these rare conditions that the child *not* be circumcised as a newborn because the preputial skin may be invaluable for scrotal construction techniques. The infant's primary physician or medical provider must be alerted to have the baby evaluated by the pediatric urologist or surgeon prior to contemplating a neonatal circumcision because they are for possible penile abnormalities such as hypospadias, chordee, or penile torsion.

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CHAPTER 107 AUGMENTATION CYSTOPLASTY IN CHILDREN

NORA G. LEE AND HANS G. POHL

Dedicated to W. H. Hendren, whose creative use of intestine in urologic reconstruction, I have been honored to observe.

Neuropathicity, bladder outlet obstruction, or embryologic abnormalities may result in a bladder too small or too hypertonic to provide normal storage and evacuation of urine. The goal of augmentation cystoplasty in the pediatric patient is to provide a sufficiently capacious reservoir that stores urine at low pressure and as a result improves urinary continence and prevents upper urinary tract deterioration. A variety of complications are possible following enterocystoplasty including, but not limited to, metabolic derangements, calculus formation, gastrointestinal disturbances, and spontaneous perforation. In this chapter, we will discuss the options for using stomach, bowel, and ureter in augmentation cystoplasty.

DIAGNOSIS

Radiographic evidences of a high-pressure neuropathic bladder (NB), such as trabeculation, elongation, or high-grade vesicoureteral reflux, are relative indications used by some but not sufficient to make the diagnosis. Instead, the decision to proceed with augmentation cystoplasty is predicated on identifying a small-capacity, noncompliant, or hypertonic bladders as a result of neuropathicity from myelodysplasia or traumatic spinal cord injury, or myogenic failure from posterior urethral valves. Occasionally, augmentation cystoplasty is also required in order to provide adequate bladder volume in cases of classic exstrophy, cloacal exstrophy, and cloacal malformations.

INDICATIONS FOR SURGERY

When urodynamic evidence exists that nonoperative measures have failed, augmentation cystoplasty is indicated. Intravesical storage pressure that has been demonstrated to be greater than 40 cm H_2O is the most robust indication for augmenting the bladder. Incontinence and urinary tract infections, with or without vesicoureteral reflux, are associated symptoms that may benefit from enterocystoplasty. However, a thorough evaluation is warranted in order to ascertain what type of augmentation to perform and whether a secondary procedure is indicated in addition to enterocystoplasty to provide continence and/or prevent upper tract deterioration.

Evaluation of Anatomic and Functional Characteristics

Vesicoureteral Reflux

Vesicoureteral reflux, found in 3% to 5% of newborns with neuropathic bladder dysfunction (detrusor hypertonicity and detrusor-sphincter dyssynergia), increases in prevalence when clean intermittent catheterization (CIC) and anticholinergic medications have not been initiated at birth: 30% at age 5 years and up to 60% in older children (1,2). Conversely, vesicoureteral reflux (VUR) resolves in 30% to 55% of patients with neuropathic bladders when CIC and anticholinergics are instituted (3–5). Since the combination of urinary infection, detrusor hyperreflexia, and VUR poses a significant risk for renal scarring, antireflux surgery should be considered at the time of augmentation cystoplasty when reflux is high-grade or recurrent symptomatic urinary infection has occurred. However, reimplanting ureters into a thick-walled bladder is challenging technically and has been associated with postoperative ureteral obstruction, leading some to consider augmentation without ureteral reimplantation. When children with neuropathic bladders and VUR have undergone augmentation cystoplasty alone, VUR has frequently resolved or been significantly downgraded without the need for reimplantation, even in cases of high-grade VUR (6).

Sphincteric Incontinence

Sphincteric incontinence may coincide with detrusor hyperreflexia in which case a procedure to increase bladder outlet resistance is indicated at the time of augmentation. If bladder outlet surgery is entertained in conjunction with enterocystoplasty, the incontinence procedure should be performed prior to opening the peritoneal cavity in order to minimize insensible fluid loss. In addition, it is of critical importance that the surgeon ascertains that the bladder neck procedure does not make catheterization difficult because ineffective emptying can lead to any one of a number of complications, thus mitigating the benefits of enterocystoplasty.

Evaluation of the Bowel

In the child with no prior history of bowel resection or gastrointestinal comorbidity, it is generally not necessary to evaluate the intestinal tract. However, radiologic imaging is essential in patients with intestinal atresia, intestinal malrotation, and imperforate anus because it is likely that anatomic abnormalities or prior surgical intervention would obviate the use of specific bowel segments. In the most severe circumstances, urogenital and anorectal anomalies coexist (cloacal exstrophy and cloacal malformation) and require an individualized and often creative use of intestinal segments in order to provide urinary storage and emptying, evacuation of feces, and sexual function, whereas alimentary function is preserved. These cases will not be discussed because they are beyond the scope of this chapter. However, helpful references are available to assist the urologic surgeon in the proper management of these patients (7).

ALTERNATIVE THERAPY

Bladder dysfunction should initially be treated with anticholinergic medications and CIC in an effort to diminish uninhibited bladder contractions, improve compliance, and provide regular and effective bladder emptying. Also, injection of botulinum toxin into the detrusor wall has been shown to improve bladder dynamics and postpones the need for augmentation cystoplasty.

SURGICAL TECHNIQUE

Preoperative Counseling

Preoperative preparation must include a thorough review of the anticipated goals of the surgery with the parent and patient, when he or she is an older child or adolescent. During this meeting, the family's ability to comply with the postoperative care of a bladder augmented with bowel must be assessed. When CIC has been performed preoperatively, the postoperative catheterization and irrigations are more readily adhered to. Urinary infection, bladder calculi, or perforation may result when routine emptying and augment cleansing is not performed regularly. Table 107.1 outlines the most common complications of augmentation cystoplasty in the early and late postoperative periods. Some complications are specific to the method of augmentation cystoplasty performed, but the most serious, perforation, occurs whenever CIC is not rigorously performed and is not restricted to any one type of enterocystoplasty.

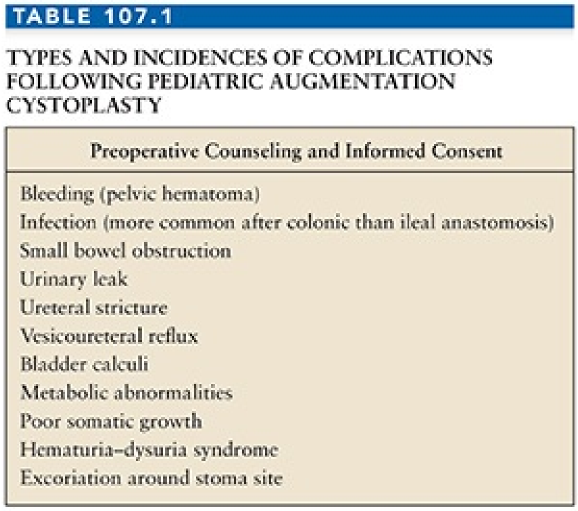

TABLE 107.1

TYPES AND INCIDENCES OF COMPLICATIONS FOLLOWING PEDIATRIC AUGMENTATION CYSTOPLASTY

Preoperative Counseling and Informed Consent
Bleeding (pelvic hematoma)
Infection (more common after colonic than ileal anastomosis)
Small bowel obstruction
Urinary leak
Ureteral stricture
Vesicoureteral reflux
Bladder calculi
Metabolic abnormalities
Poor somatic growth
Hematuria–dysuria syndrome
Excoriation around stoma site

Preoperative Bowel Preparation

The patient with neurogenic bladder dysfunction is likely to have coexistent constipation, thus necessitating that the bowel preparation be started well in advance. The patient should be contacted with explicit instructions to begin clear liquids at home 2 days prior to surgery and to arrive early for a preoperative admission 1 day prior to surgery. Intravenous fluids should be started at the same time that the patient begins ingestion (orally or by nasogastric tube) of GoLYTELY solution (Table 107.2). Enemas and oral antibiotics are administered as well following completion of the GoLYTELY prep, depending on the severity of the patient's fecal load and estimated efficacy of the oral bowel prep. For patients with marginal renal function, the use of phosphate containing laxatives is contraindicated. Instead, twice-daily oral administration of polyethylene glycol 3350 beginning 3 days preoperatively as an adjunct to a clear liquid diet is sufficient to clear most children.

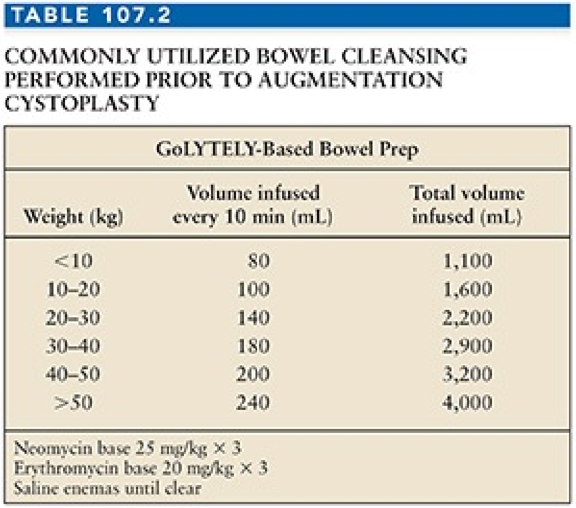

TABLE 107.2

COMMONLY UTILIZED BOWEL CLEANSING PERFORMED PRIOR TO AUGMENTATION CYSTOPLASTY

GoLYTELY-Based Bowel Prep		
Weight (kg)	Volume infused every 10 min (mL)	Total volume infused (mL)
<10	80	1,100
10–20	100	1,600
20–30	140	2,200
30–40	180	2,900
40–50	200	3,200
>50	240	4,000

Neomycin base 25 mg/kg × 3
Erythromycin base 20 mg/kg × 3
Saline enemas until clear

Selection of Bowel Segment to Use

There is no ideal segment of bowel for augmentation cystoplasty; each has a set of characteristics that are advantages or liabilities depending on the clinical scenario (Table 107.3). The following section will review the aspects of each intestinal segment that sets it apart from the remainder in the context of the results and complications following enterocystoplasty. It should be noted that none of these complications are seen following ureterocystoplasty, making it the ideal tissue for bladder augmentation (8,9). However, it is a procedure ideally performed in a patient with a severely dilated ureter that subtends a nonfunctioning kidney. Ironically, most patients with neuropathic bladder dysfunction rarely present with such anatomy as a result of close follow-up and the early institution of anticholinergic medications and CIC. Currently, boys with posterior urethral valves are most likely to present with severely hydronephrotic kidneys and massively dilated ureters that can be used to augment the bladder. In those circumstances, ureterocystoplasty has achieved comparable capacity and compliance as with enterocystoplasty (8).

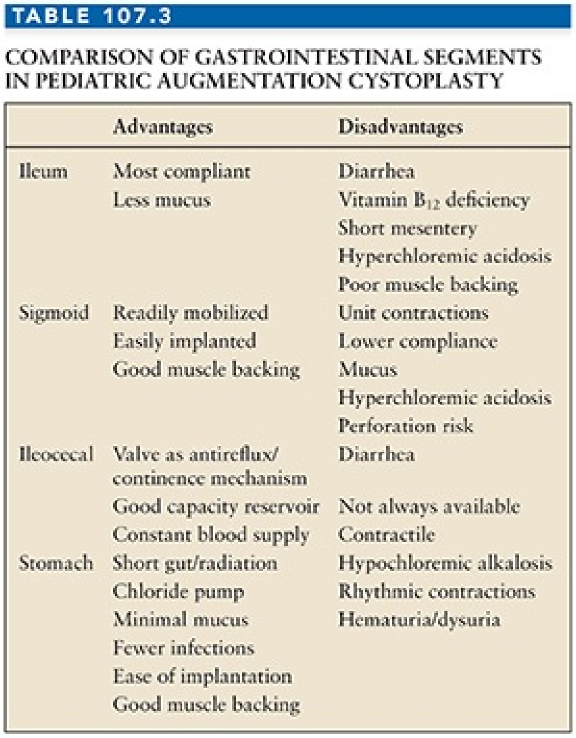

TABLE 107.3

COMPARISON OF GASTROINTESTINAL SEGMENTS IN PEDIATRIC AUGMENTATION CYSTOPLASTY

	Advantages	Disadvantages
Ileum	Most compliant	Diarrhea
	Less mucus	Vitamin B_{12} deficiency
		Short mesentery
		Hyperchloremic acidosis
		Poor muscle backing
Sigmoid	Readily mobilized	Unit contractions
	Easily implanted	Lower compliance
	Good muscle backing	Mucus
		Hyperchloremic acidosis
		Perforation risk
Ileocecal	Valve as antireflux/ continence mechanism	Diarrhea
	Good capacity reservoir	Not always available
	Constant blood supply	Contractile
Stomach	Short gut/radiation	Hypochloremic alkalosis
	Chloride pump	Rhythmic contractions
	Minimal mucus	Hematuria/dysuria
	Fewer infections	
	Ease of implantation	
	Good muscle backing	

Intraoperative Preparation of the Patient

The patient is positioned supine on the operating table. General anesthesia with endotracheal intubation is mandatory; however, if no spinal abnormality exists that contraindicates the use of an epidural catheter, consideration should be given to regional anesthesia as well. The surgical field is prepared and draped from the xiphoid process inferiorly, including the genitalia. A Foley catheter is inserted urethrally. A midline incision is created beginning at the symphysis pubis an extending superiorly toward the umbilicus. In order to avoid the insensible loss of heat and water from peritoneal surfaces, it is recommended that any concomitant procedures on the bladder or bladder neck be performed through a limited incision that does not enter the peritoneal space. Retraction can be provided by either a Denis Browne or Bookwalter retractor at this point.

Preparation of the Bladder for Cystoplasty

When a continent diversion is not planned, a midline cystotomy suffices to prepare the bladder for augmentation (Fig. 107.1). Ureteral reimplants can be easily performed at this point. However, when a continent catheterizable stoma is planned, either a paramedian or transverse cystotomy should be considered since these incisions create bladder flaps that facilitate the creation of a long submucosal tunnel for the appendix or ileal tube. Regardless of the bladder incision created, it must be sufficiently long to open the bladder widely. If the cystotomy is too short, the augmented segment may behave as a diverticulum, thus facilitating urinary stasis and stone formation. Once the bladder has been prepared, the midline incision is carried above the umbilicus and the peritoneum is entered. Retraction at this point is provided by a Bookwalter retractor.

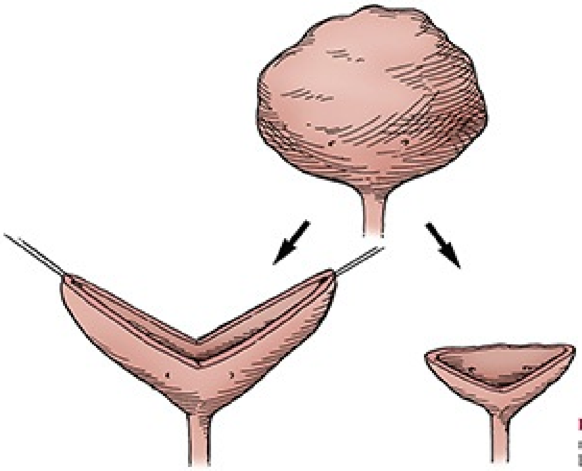

FIGURE 107.1 **A:** Preparation of the bladder for clam augmentation cystoplasty. **B:** Sagittal incision is made to create two bladder flaps.

Should one encounter an augmented bladder in which the intestinal segment has formed a pseudodiverticulum the following technique has been helpful. Create a cystotomy incision that transects the anterior lip of the opening into the intestinal segment. Through this cystotomy, incise the posterior lip of the opening with electrocautery until it is seen to spring open. This incision is not full-thickness. This defect should be closed transversely with continuous 3-0 polyglycolic acid (PGA), thus completing a Heineke-Mikulicz–like repair. The anterior cystotomy should then be closed transversely as well. (Author's personal observation of W. H. Hendren)

Ileocystoplasty

Ileum is by far the most popular segment used for bladder augmentation. The segment, 20 to 25 cm long, is based on a pedicle that is supplied by branches of the superior mesenteric artery and that is sufficiently mobile to be brought into the pelvis (Fig. 107.2). On occasion, an abnormally thick, fatty, or short mesentery can limit mobility of the vascular pedicle, thus necessitating extensive division of the mesentery posteriorly. The terminal 15 to 20 cm of ileum, as measured from the ileocecal valve proximally, is spared in order to retain bile salt absorption, thus preventing steatorrhea and vitamin B_{12} deficiency (Fig. 107.3). The portion of ileum to be used is measured, and 5-0 silk sutures used to mark the proximal and distal limits of resection. Prior to dividing the mesentery, the vascular supply to the isolated segment should be observed by transillumination and the proposed incisions in the mesentery marked. Beginning at the mesenteric border of the bowel, the mesentery is divided between pairs of fine hemostats, and the vascular arcades are ligated with 5-0 silk suture ties. The bowel is then divided between atraumatic bowel clamps that have been applied at the proximal and distal limits of resection. Once the ileal segment reaches into the pelvis without tension on the vascular pedicle, no further mesenteric division is needed. An ileoileal anastomosis is performed cephalad to the isolated ileal segment and the mesenteric trap is closed. The bowel clamps are removed and a thorough lavage of the ileal segment is performed with sterile saline. It is the preference of the authors to configure the ileal segment into a U configuration (Fig. 107.4). The antimesenteric border of the ileal segment can then be opened using scissors or the cutting current with little concern for bleeding that usually ceases spontaneously. The segment is folded 180-degrees and the adjoining edges are sutured as full-thickness using continuous locking 4-0 PGA. Once the ileal cap has been formed, it is anastomosed to the opened bladder beginning at the most posterior portion of the bladder incision (Fig. 107.5). Hemostatic clamps may be left on the short ends of the tied sutures in order to identify the most posterior limit of the anastomotic line, thus facilitating placement of the second, reinforcing suture layer between the serosal surfaces of the bladder and ileum. A suprapubic catheter is placed through the bladder wall prior to completion of the first anastomotic closure (Fig. 107.6).

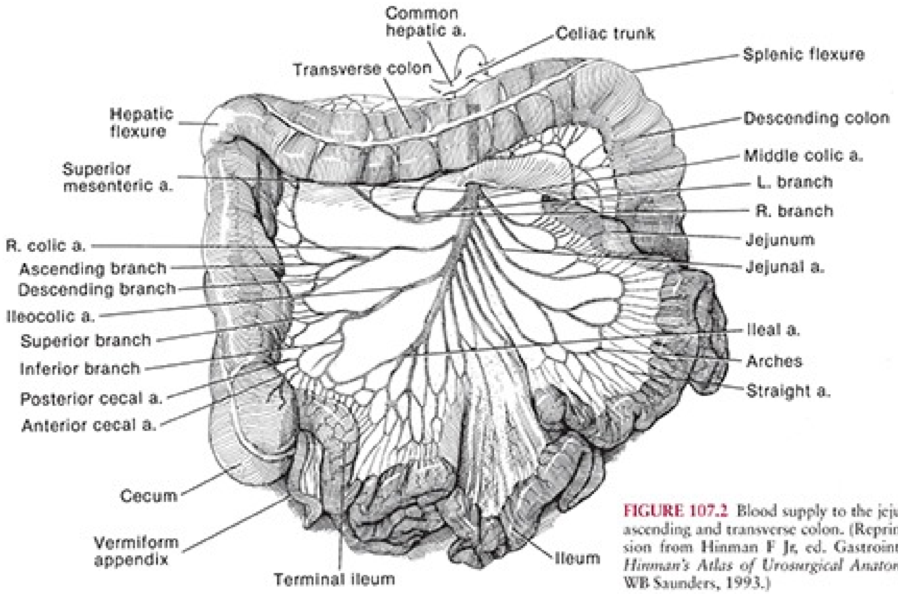

FIGURE 107.2 Blood supply to the jejunum, ileum, and ascending and transverse colon. (Reprinted with permission from Hinman F Jr, ed. Gastrointestinal tract. In: *Hinman's Atlas of Urosurgical Anatomy*. Philadelphia: WB Saunders, 1993.)

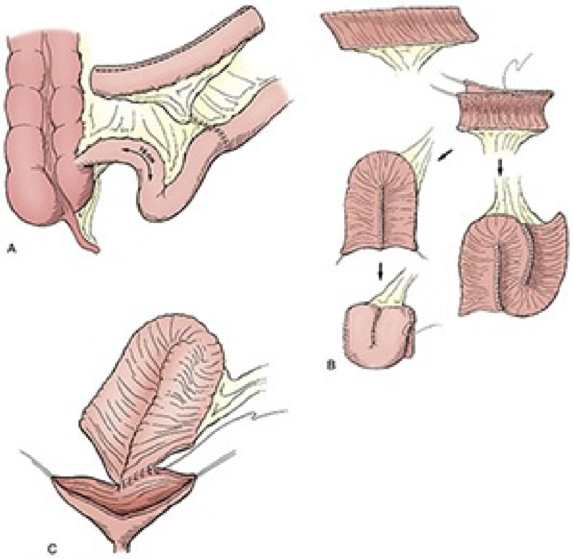

FIGURE 107.3 Ileocystoplasty. **A:** 20- to 40-cm segment of ileum at least 15 cm from the ileocecal valve is removed and opened on its antimesenteric border. Ileoileostomy reconstitutes the bowel. **B:** The opened ileal segment is reconfigured. This can be done in a U, S, or W configuration. It can be further folded as a cup patch. **C:** The reconfigured ileal segment is anastomosed widely to the native bladder. (Reprinted with permission from Adams MC, Joseph DB. Urinary reconstruction in children. In: Wein AJ, Kavoussi LR, Novick AC, et al, eds. *Campbell's Urology*, 9th ed. Philadelphia: WB Saunders, 2007.)

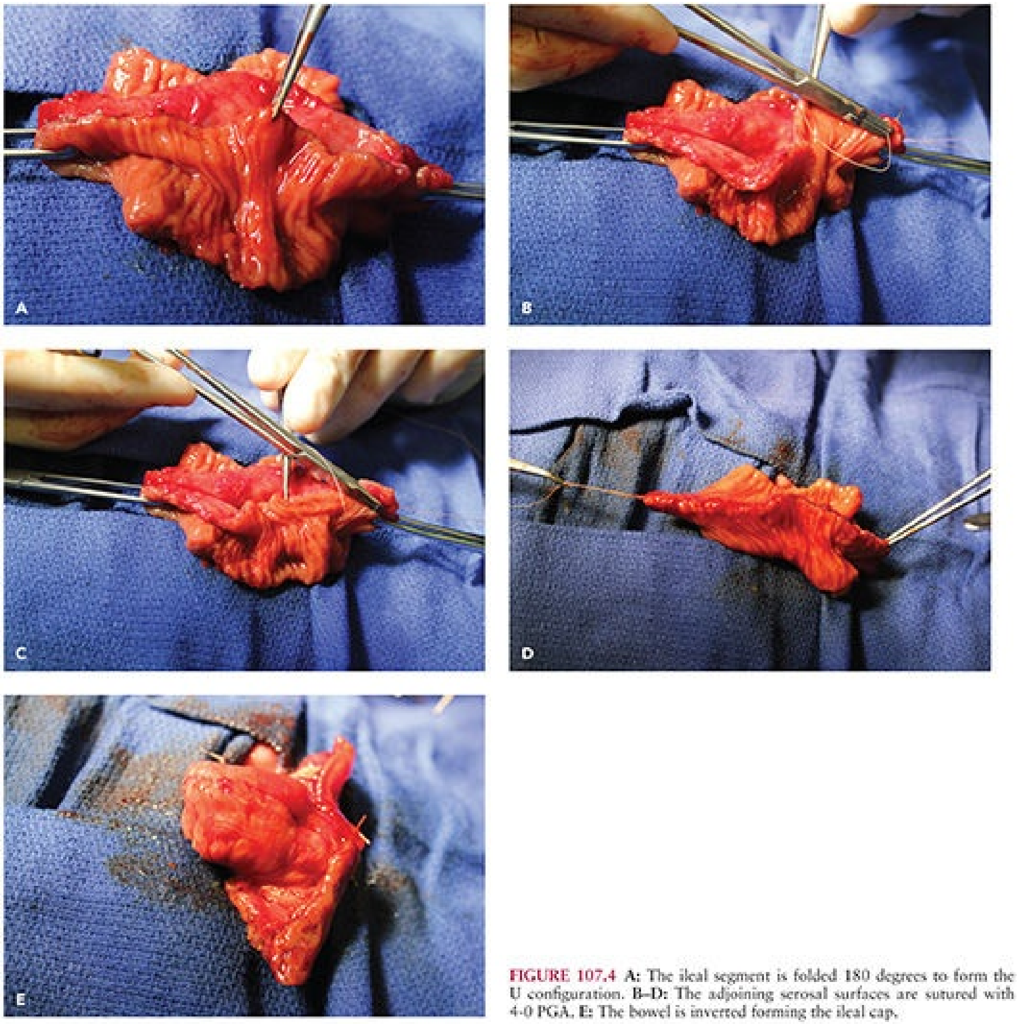

FIGURE 107.4 **A:** The ileal segment is folded 180 degrees to form the U configuration. **B–D:** The adjoining serosal surfaces are sutured with 4-0 PGA. **E:** The bowel is inverted forming the ileal cap.

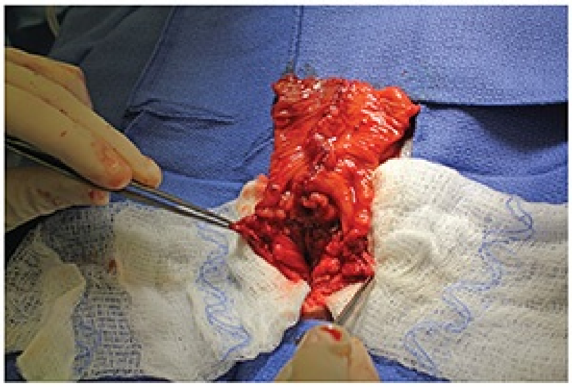

FIGURE 107.5 The ileal cap is anastomosed to the opened bladder starting posteriorly.

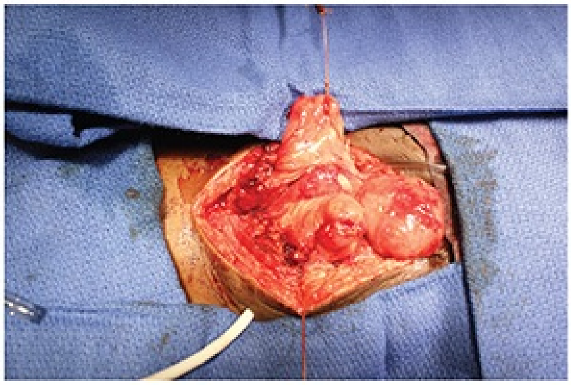

FIGURE 107.6 The completed augmentation cystoplasty anastomosis. The suture tags are on the lateral aspects of the anastomosis. The white suprapubic tube is placed laterally.

Right Colocystoplasty and Mainz Enterocystoplasty

Enterocystoplasty with a segment of ascending colon is based on vascular supply from the ileocolic artery (see Fig. 107.2). Dissection begins at the inferior edge of the cecum and progresses cephalad along the line of Toldt, the peritoneal reflection lateral to the right colon. At the hepatic flexure, the hepatocolic ligament must be divided. Next, the omental attachments to the colon are divided and the omentum is packed into the left upper quadrant with moist lap sponges. The ascending colon is divided at the watershed between the ileocolic and right colic arteries, approximately midway between the cecum and hepatic flexure. The ileum is divided close to the ileocecal valve. An ileocolonic anastomosis is performed and the mesenteric trap is closed. If the appendix will not be used to create a continent catheterizable stoma, an appendectomy is performed at this point. The bowel is folded 180 degrees and the serosal surfaces sutured with 4-0 PGA. The bowel is incised along its antimesenteric border and the edges are sutured full thickness with 4-0 PGA placed in a continuous fashion. The resulting colonic plate is folded once again. This time the full-thickness suture line is placed first and reinforced with a second continuous line of 4-0 PGA. The resulting cup is inverted and anastomosed to the bladder opening as described for the ileocystoplasty. An alternative approach that has gained wide popularity is the Mainz augmentation in which 15 to 30 cm of terminal ileum are isolated in continuity with the right colon and detubularized, anastomosed to each other, and sutured to the cystotomy (Fig. 107.7).

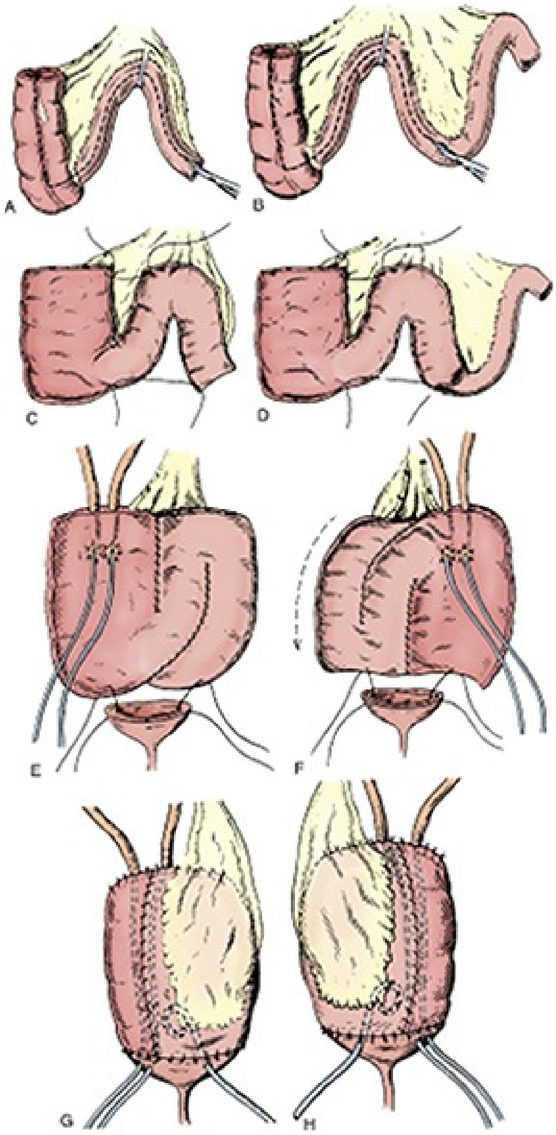

FIGURE 107.7 Mainz ileocecocystoplasty. A and B: The ileal segment is twice the length as the cecal segment. C and D: It is opened on the antimesenteric border. E and F: The ureters can be opened into the opened cecal segment if necessary. G and H: The ileocecal segment is anastomosed to the native bladder. (Reprinted with permission from Thuroff JW, Alken P, Riedmiller H, et al. The Mainz pouch. In: King LR, Stone AR, Websterm GD, et al, eds. *Bladder Reconstruction and Continent Urinary Diversion*. Chicago, IL: Year Book, 1987.)

Sigmoidocystoplasty

Since the diameter of the sigmoid is much greater than that of the ileum, a shorter segment is necessary in order to perform a successful augmentation cystoplasty. The isolated segment derives its blood supply from the sigmoid branches of the inferior mesenteric artery (Fig. 107.8). A mesenteric incision is created proximally and distally and bowel clamps applied to minimize fecal soiling. The sigmoid is divided, and a sigmoidosigmoidostomy performed lateral to the mesentery of the isolated segment (Fig. 107.9). (It is advisable for each surgeon to standardize the side where they perform the sigmoidosigmoidostomy in the event that reoperation is necessary in the future.) Two methods are available for anastomosing the bowel segment to the bladder. In the first, the proximal and distal ends of the segment are closed, and the bowel is opened along its antimesenteric border and sutured to the bladder opening. In the second, the bowel is opened along its antimesenteric border first and then folded 180 degrees into a U shape prior to suturing it to the bladder. The latter method likely disrupts the high unit contractions of the sigmoid more than the first; however, it requires that a greater length of sigmoid be isolated.

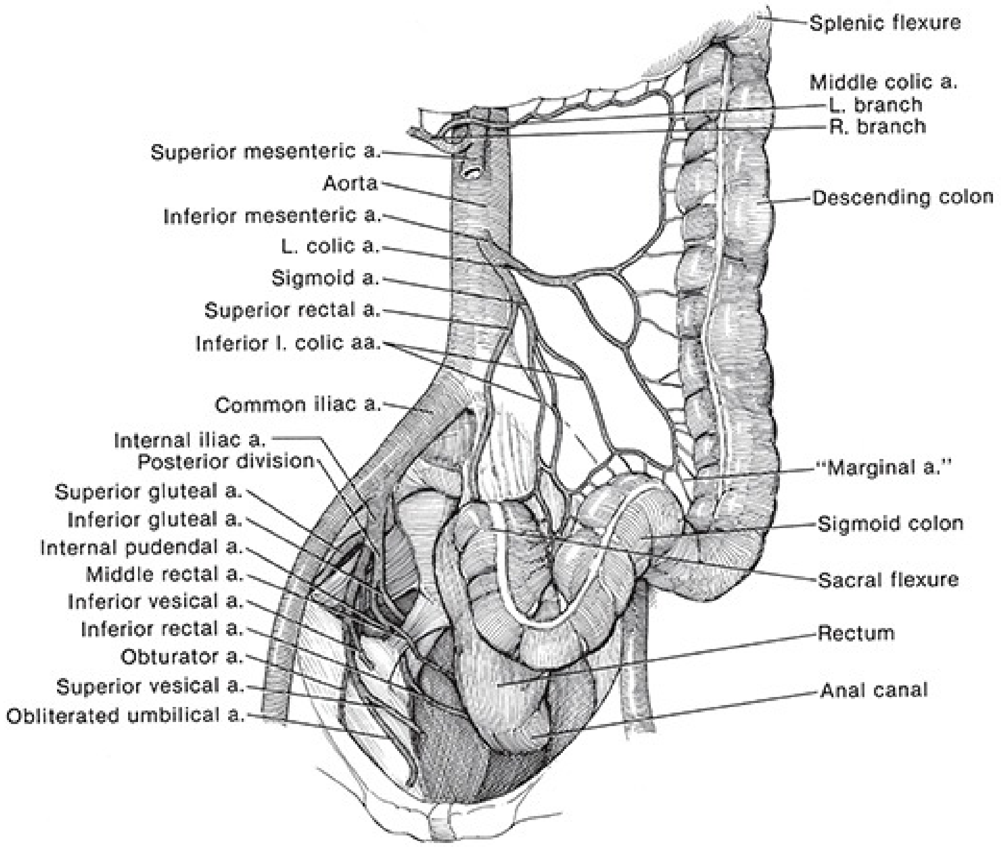

FIGURE 107.8 Blood supply to the descending and sigmoid colon and rectum. (Reprinted with permission from Hinman F Jr, ed. Gastrointestinal tract. In: *Hinman's Atlas of Urosurgical Anatomy*. Philadelphia: WB Saunders, 1993.)

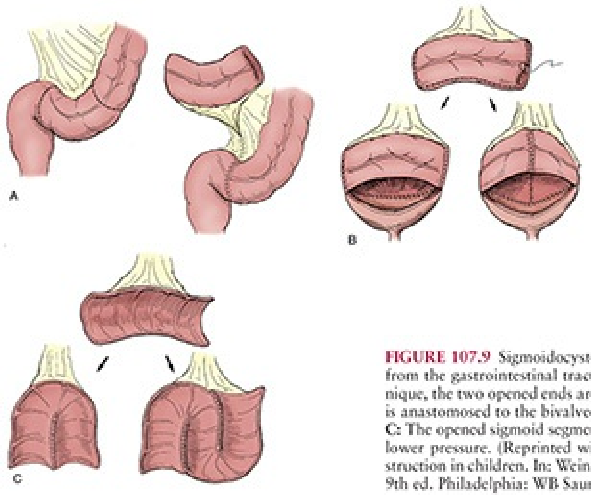

FIGURE 107.9 Sigmoidocystoplasty. **A:** A sigmoid segment of adequate length is removed from the gastrointestinal tract and a colocolostomy is performed. **B:** In the Mitchell technique, the two opened ends are closed. The antimesenteric border is incised and the segment is anastomosed to the bivalved bladder. It may be rotated 180 degrees to allow an easy fit. **C:** The opened sigmoid segment can be reconfigured into a U or S configuration, which may lower pressure. (Reprinted with permission from Adams MC, Joseph DB. Urinary reconstruction in children. In: Wein AJ, Kavoussi LR, Novick AC, et al, eds. *Campbell's Urology*, 9th ed. Philadelphia: WB Saunders, 2007.)

Gastrocystoplasty

The bladder may be augmented with a gastric segment derived from either the antrum or the body of the stomach. When antral gastrocystoplasty is performed, the enteric stream is reconstructed using a Billroth I anastomosis (gastroduodenostomy). This procedure is now rarely performed in children since resection of the antrum has been associated with delayed gastric emptying, gastric dumping syndrome, and feeding difficulties. Currently, most surgeons prefer the use of the stomach body instead. A segment between 10 and 20 cm is marked along the greater curvature of the stomach and drawn as a rhomboid that extends toward the lesser curvature, ending 1 cm from the edge so as not to interrupt branches of the vagus nerve. Two arterial supplies exist to the greater curvature of the stomach: (a) the right gastroepiploic artery, derived from the right gastric artery, and (b) the left gastroepiploic artery, from the splenic artery (Fig. 107.10). If the right gastroepiploic artery is chosen, the gastric segment should be obtained from higher on the greater curvature, lower if based on the left (Fig. 107.11). The gastroepiploic arteries supply the stomach with anterior and posterior branches that must be divided before the segment can be excised from the stomach. Atraumatic intestinal clamps are applied in parallel at the proposed incision sites on the stomach. Alternatively, an intestinal stapling device can be used to divide the stomach; however, the staples must be removed later. The vascular pedicle must be retroperitonealized in order to prevent internal hernia formation. A window is created in the transverse mesocolon that accepts the gastric augment and its vascular pedicle. The segment is passed posterior to the mesocolon and exits a second window that has been created in the small bowel mesentery inferiorly. If the vascular pedicle is too short, additional branches between the gastroepiploic artery and the stomach must be divided. The stomach is sutured to the bladder beginning along the posterior aspect of the cystotomy.

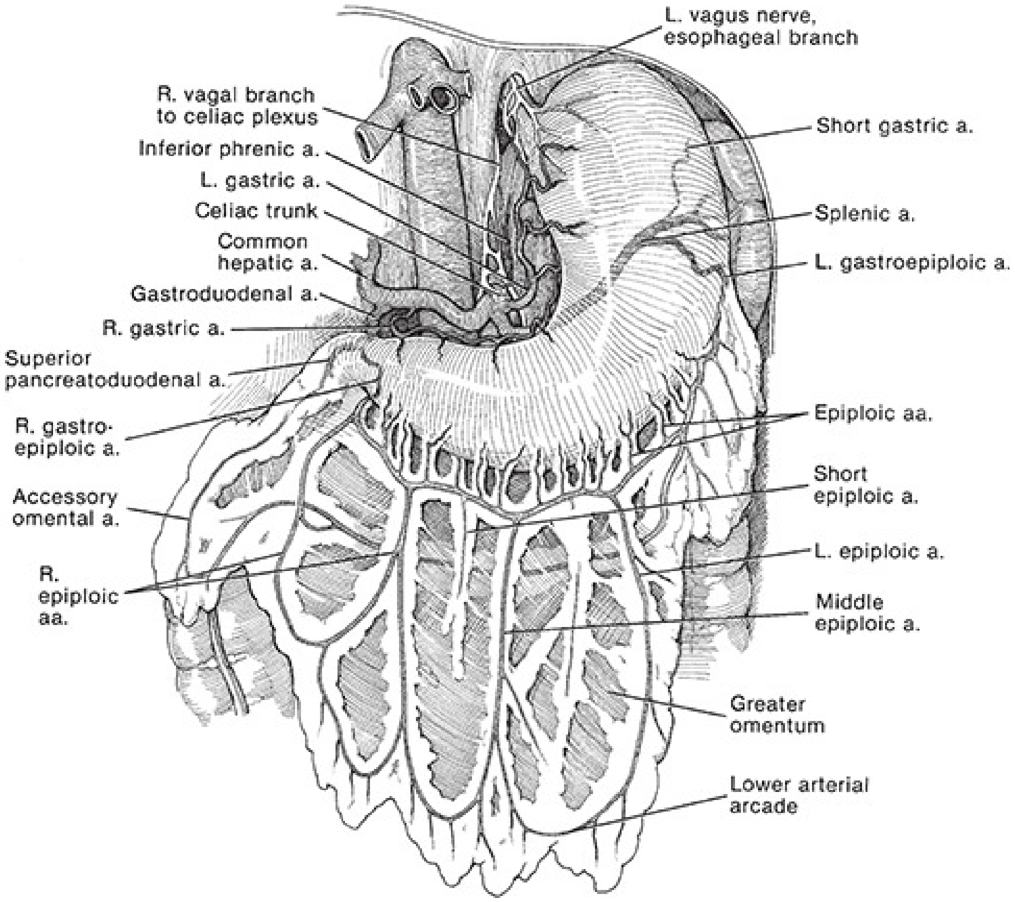

FIGURE 107.10 Blood supply to the anterior aspect of the stomach and greater omentum. (Reprinted with permission from Hinman F Jr, ed. Gastrointestinal tract. In: *Hinman's Atlas of Urosurgical Anatomy*. Philadelphia: WB Saunders, 1993.)

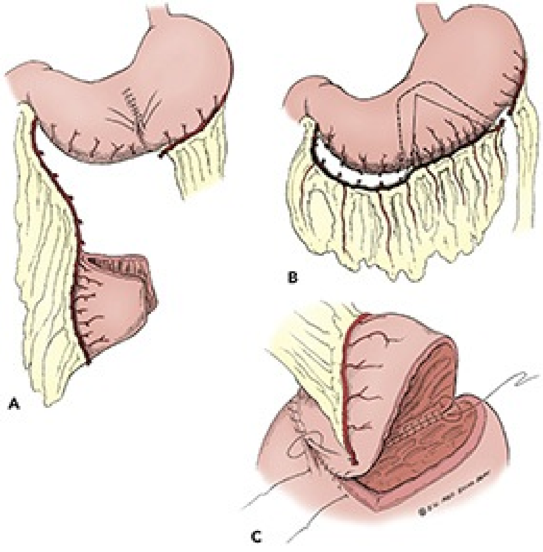

FIGURE 107.11 Gastrocystoplasty using the body of the stomach. **A:** A gastric segment of the body is mobilized on the right gastroepiploic artery. The left vessel may also be used; neither vessel as a pedicle should be free floating through the peritoneum. **B:** A longer gastric segment along the greater curvature with a wider apex provides more surface area for augmentation. **C:** The gastric segment is anastomosed to the bivalved bladder with the mucosa inverted. (Reprinted with permission from Adams MC, Joseph DB. Urinary reconstruction in children. In: Wein AJ, Kavoussi LR, Novick AC, et al, eds. *Campbell's Urology*, 9th ed. Philadelphia: WB Saunders, 2007.)

Ureterocystoplasty

Unlike enterocystoplasty, ureterocystoplasty does not require a midline transperitoneal incision. The entire procedure can be performed retroperitoneally through a flank incision, to perform the nephrectomy and harvest the proximal portion of the ureter, and a Pfannenstiel incision, through which the augmentation is performed. Only a midline incision should be considered when two functioning kidneys exist, since a transureteroureterostomy will be required in order to reestablish continuity of the upper urinary tract after distal ureter has been harvested (Fig. 107.12). Following the nephrectomy, careful mobilization of the ureter from its retroperitoneal location includes dissection of all surrounding adventitia away from the peritoneal lining toward the ureter itself. The ureter is then passed into the pelvis. A midline cystotomy is created such that the posterior portion of the incision includes the ureterovesical junction. The ureter, too, is incised along its anterior aspect. A spherical reservoir can be created by folding the proximal end of the ureter toward the cystotomy in an inverted U and suturing the adjoining edges of the ureter to itself. The remainder of the anastomosis between the ureter and the bladder is performed as in enterocystoplasty, beginning at the posterior aspect of the cystotomy and proceeding in an anterior fashion. Drainage tubes are placed through the native bladder muscle tissue.

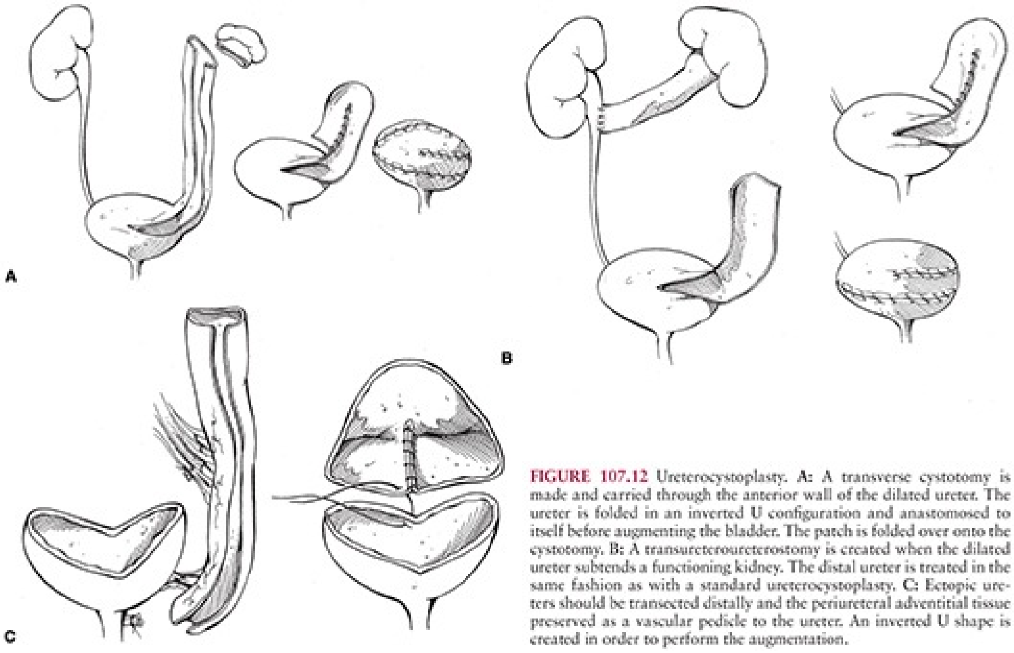

FIGURE 107.12 Ureterocystoplasty. **A:** A transverse cystotomy is made and carried through the anterior wall of the dilated ureter. The ureter is folded in an inverted U configuration and anastomosed to itself before augmenting the bladder. The patch is folded over onto the cystotomy. **B:** A transureteroureterostomy is created when the dilated ureter subtends a functioning kidney. The distal ureter is treated in the same fashion as with a standard ureterocystoplasty. **C:** Ectopic ureters should be transected distally and the periureteral adventitial tissue preserved as a vascular pedicle to the ureter. An inverted U shape is created in order to perform the augmentation.

Urinary and Abdominal Drainage Following Augmentation Cystoplasty

If an incontinence procedure has not been performed, an appropriately sized urethral Foley catheter is used. However, since the retention balloon can cause pressure necrosis of the bladder neck following incontinence procedures, some surgeons would instead use a Rob-Nel catheter or Silastic feeding tube that may be secured with 3-0 silk sutures passed through the bladder and abdominal wall and tied over a cotton bolster. Additionally, a suprapubic Malecot catheter should be placed through a separate incision in the native bladder and brought out through the anterior abdominal wall. It is advised that this tube in particular be secured with 3-0 nylon sutures. Irrigation with sterile saline should be instituted on postoperative day 3 in an effort to cleanse the newly augmented bladder free of the copious amounts of mucus that the enteric segments produce. Jackson-Pratt closed-system vacuum drains may be employed briefly following surgery and removed when minimal peritoneal drainage exists. In patients with ventriculoperitoneal shunts, cerebrospinal fluid can be confused for persistent peritoneal drainage. Particularly in these patients, the surgeon should resist temptation to maintain these drains for an extended period of time.

Postoperative Follow-up

Three weeks postoperatively, the urethral catheter or catheter within the catheterizable stoma should be removed leaving the suprapubic tube in place for safety. A cystogram may be performed to demonstrate a healed anastomosis prior to catheter removal. In cases of continent catheterizable stoma placement, patients should learn to CIC at this time and cap the suprapubic tube. Once the patient adequately demonstrates he or she can catheterize without problems, the suprapubic tube may be used.

COMPLICATIONS

Gastrointestinal Effects

The two most likely gastrointestinal complications following augmentation cystoplasty in children are diarrhea and vitamin B_{12} deficiency (each in up to 23%). Small bowel obstruction may occur in approximately 3% of patients and is no more likely with any one particular segment of bowel. Gastrocystoplasty is associated with a greater risk for small bowel obstruction as a function of the difficulty in retroperitonealizing the vascular pedicle to the gastric patch. The potentially free-floating pedicle can permit internal herniation of bowel loops that in later stages compromises vascularity to the gastric patch itself.

Diarrhea, a complication most often found following the use of the ileocecal valve (up to 23%), may also be seen after standard ileocystoplasty, although less frequently (11%). For this reason, use of the ileocecal valve is not advocated when other segments will serve just as well. The sigmoid, for instance, dilates and lengthens as a consequence of constipation, thus affording the surgeon a more redundant segment with which to augment. An additional advantage of sigmoid is its proximity to the bladder.

Vitamin B_{12} deficiency can be avoided by limiting the length of small bowel harvested and in particular by preserving the terminal 20 cm of ileum, the major site of B_{12} absorption. Ileocecal augmentation cystoplasty carries a greater risk for vitamin B_{12} deficiency (23%) as compared with standard ileocystoplasty (11%), yet one is unlikely to encounter this deficiency at all since in the majority of circumstances a limited portion of nonterminal ileum is employed. However, when vitamin B_{12} absorption is hampered, the deficiency may not manifest for at least 3 years since body stores are sufficiently ample to maintain serum levels. Vitamin B_{12} may be administered prophylactically as an intramuscular injection beginning 3 years after enterocystoplasty. Alternatively, serum levels may be assessed periodically and replacement vitamin B_{12} administered as appropriate.

Metabolic Effects

Ileocystoplasty and Colocystoplasty

Despite the incorporation of intestine into the urinary tract, its absorptive and secretory capacity is retained: Chloride, ammonium, hydrogen ions, and organic acids are readily absorbed and bicarbonate ions are secreted into the urine. The resultant hyperchloremic metabolic acidosis is driven by the absorption of ammonium ions that are followed by chloride in an attempt to maintain electroneutrality. The amount of bowel used, length of time that bowel mucosa is in contact with urine, and the degree of underlying renal impairment contribute to the severity of the metabolic disturbance. Conversely, acidosis is rarely seen in patients with normal renal function, and any measurable increase in serum chloride and decrease in serum bicarbonate is subtle. Mild cases of metabolic acidosis can be managed with oral sodium bicarbonate (1 to 3 mEq/kg/day) with the goal being an increase in serum bicarbonate to a value greater than 20 mEq/L. Severe acidosis requires intravenous administration of bicarbonate, usually as dextrose 5% with 1/4 normal saline and 50 mEq/L of sodium bicarbonate. Hyperchloremic metabolic acidosis may occur following augmentation either with ileum, cecum, colon, or sigmoid but is most common following sigmoidocystoplasty.

Use of jejunum is associated with a pattern of metabolic derangement distinct from any other segment of bowel: a hypochloremic, hyponatremic, hyperkalemic metabolic acidosis. For this reason, it is recommended that jejunum not be used in pediatric augmentation cystoplasty, especially when renal function is poor.

As a consequence of the net secretion of chloride and hydrogen ions across the gastric mucosa, augmentation with stomach results in a hypochloremic metabolic alkalosis in 3% to 24% of the patients (10–14). This effect can be used to advantage in patients with renal dysfunction and acidemia, who will demonstrate decreased serum chloride and increased serum bicarbonate following gastrocystoplasty (12,15,16). In those patients whose renal dysfunction is characterized by a concentrating defect, gastrointestinal illness with vomiting can precipitate significant alkalosis that must be treated with intravenous fluid containing sodium chloride. Milder cases can be treated with oral salt supplementation, or inhibitors of histamine-2 (i.e., cimetidine) or the gastric acid H^+/K^+ ATPase pump (i.e., omeprazole) (17,18). It has also been reported that alkalosis occurs in the absence of gastrointestinal illness and may still be severe enough to require resection of a portion of the gastric segment. Alternatively, addition of ileum may balance the metabolic abnormality.

Bladder Perforation

Perforation is the most serious complication of augmentation enterocystoplasty, and patients may present critically ill despite few localizing signs and symptoms. The condition should immediately be suspected when an augmented patient presents with fever and abdominal pain no matter how mild the symptoms. Shoulder pain secondary to diaphragmatic irritation from urine in the peritoneal cavity has also been reported (19). Which gastrointestinal segment carries the greatest risk of perforation is debatable. The Indiana group reported perforations in 16.5% of sigmoid cystoplasties, 8% of gastrocystoplasties, and 4.5% of ileocystoplasties (9). Conversely, the Boston Children's Hospital experience found a greater incidence of perforations among children who had received augmentation with ileum rather than with stomach or sigmoid, 9%, 3%, and 3%, respectively (19). Therefore, any child is potentially at risk irrespective of the segment used. The underlying etiology for all perforations is believed to be ischemia within the bowel wall as a consequence of either overdistension from infrequent emptying or high-pressure contractions or even reconfiguration by detubularization (19). In addition to late perforations, intestinal anastomotic leakage occurring early following sigmoidosigmoidostomy is a liability that must be considered when using this segment, particularly in a patient with a ventriculoperitoneal shunt in whom spillage of fecal material within the peritoneum can be lethal.

Patients suspected of having bladder perforation should undergo fluid resuscitation and receive intravenous broad-spectrum antibiotics and Foley catheter drainage while the evaluation is underway. A standard cystogram may miss up to 33% of bladder perforations; therefore, computerized tomography cystograms are advocated (20). While some have successfully employed nonoperative management, surgical exploration with resection of necrotic tissue and primary closure of the defect should be performed in a gravely ill patient, or when the patient fails to improve during nonoperative management (21).

Hematuria–Dysuria Syndrome

This disadvantage, occurring in 9% to 70% of patients who have undergone a gastrocystoplasty, presents with perineal pain, dysuria, hematuria, and skin excoriation around either the urethral meatus or the stoma of a catheterizable channel (10,11,22). Sensate patients are more frequently symptomatic than those with diminished sensation, 68% as compared with 25%; however, any patient with incontinence is at risk from clinically significant hematuria–dysuria syndrome (14). A recent study of 10 children with hematuria–dysuria identified a positive correlation between the presence of infecting *Helicobacter pylori*, reduced urine pH, and the presence of symptoms following gastrocystoplasty. The authors recommend evaluating all patients who are under consideration for a gastric augment for the presence of *H. pylori* and treating the infection before performing surgery (23,24). Oral therapy with histamine-2 or H^+/K^+ ATPase blockers should be helpful in symptomatic patients. If prolonged catheterization is anticipated, then bladder irrigations should be performed with a sodium bicarbonate containing solution.

OUTCOMES

Improved Bladder Dynamics

The immediate goal of augmentation cystoplasty should be that intravesical storage pressure decreases well below the threshold of 40 cm H_2O, thus averting progressive upper tract deterioration. Although any gastrointestinal segment can provide a sufficiently compliant augment if it is very long and fully detubularized, most authors agree that, for a given length of bowel, ileum provides the greatest compliance of any segment (25–30). Of 323 patients who had undergone enterocystoplasty in one large review, 6% required an additional augmentation because of persistently elevated intravesical pressure. Colocystoplasty and gastrocystoplasty patients were 10 times more likely to need a repeat procedure as compared with those having undergone an ileocystoplasty (31). The thicker muscular wall of the cecal, ascending, and sigmoid colon segments is most likely responsible for the strong mass contractions that occur, some up to 110 cm H_2O (32). Others have noted that gastric segments in particular display rhythmic sinusoidal contractions that persist following cystoplasty in as many as 80% of patients, irrespective of the portion used (antrum versus body) (16,18,31). These findings should not entirely discourage use of gastrointestinal segments other than ileum because advantages for their application in bladder reconstruction do exist. However, consideration should be given to their use in composite grafts, such as in gastroileocystoplasty. Ureterocystoplasty, by comparison, offers an alternative to ileocystoplasty that can reliably provide similar increases in bladder capacity and compliance without the gastrointestinal, metabolic, infectious, and lithogenic complications of enterocystoplasty (8).

Urinary Tract Infection

Regardless of the segment chosen, persistent bacteriuria is common following augmentation cystoplasty occurring up to 95% (33,34). The Indiana group reported symptomatic urinary tract infection in 23% of ileocystoplasties, 17% of colocystoplasties, 13% of cecocystoplasties, and only 8% of gastrocystoplasties which suggests that bacterial colonization may be impeded by the reduced urine pH in bladders augmented with stomach. Overall, 13% of patients had febrile urinary infections, and although gastrocystoplasties were less likely to be associated with febrile UTI, statistical significance was not met. A more recent study identified a positive urine culture in 95% of colocystoplasty patients, and only 13% of patients receiving a gastric patch augment furthering the notion that gastric augments are protective against colonization (33). Despite these data, others have reported a greater incidence of asymptomatic bacteriuria (66%) and symptomatic UTI (25%) in patients who had undergone a gastrocystoplasty than had previously been demonstrated, thus dispelling conventional wisdom (15). Symptomatic cystitis, defined as incontinence, suprapubic pain, foul-smelling urine and perhaps increased mucus production, may be more likely when CIC is performed sporadically and incompletely or when mucus and stones serve as a nidus for colonizing bacteria. Any patient with symptomatic UTI should be considered for antimicrobial therapy irrespective of the form of augmentation performed.

Calculi Formation and Mucus Production

The reported incidence of bladder calculi has ranged between 8% and 52% of patients following augmentation cystoplasty, yet the occurrence of bladder calculi may not be a specific complication of augmentation cystoplasty (34–38). Instead, poor patient compliance with CIC, colonization with urea-splitting bacteria, and the presence of mucus to serve as a nidus for the aggregation of salts may be the trifecta that results in calculus formation. Barroso et al. (39) found a similar incidence of bladder calculi in patients performing CIC with (10%) and without (7%) augmented bladders: overall, 64% were asymptomatic and 88% had chronic bacteriuria. Fifty percent of the patients demonstrated difficulty in catheterization whether performed via urethra or Mitrofanoff channel, thus implicating residual urine in the genesis of calculi (39). Commonly composed of magnesium ammonium phosphate (struvite), bladder calculi are most likely the result of persistent bacteriuria with urease-producing organisms. However, an inherent predisposition for struvite stone formation has been found in some individuals whose mucus contains increased amounts of calcium, magnesium, and phosphate (40). Additionally, some stone formers who had been identified as hypocitraturic have been treated with oral potassium citrate, thus averting recurrent stone formation (38). By virtue of lesser mucus production and bacteriuria than either ileum or colon, stomach is least likely to be associated with bladder calculi. Mucus production from ileal segments does decrease over time as a result of villous atrophy, a feature not characteristic of colonic epithelium.

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CHAPTER 108 THE MITROFANOFF AND MALONE ANTEGRADE CONTINENCE ENEMA PROCEDURES IN PEDIATRIC URINARY TRACT RECONSTRUCTION

MARK P. CAIN

MITROFANOFF PROCEDURE

The Mitrofanoff principle has now been used for over 30 years but still stands as one of the major advancements to continent urinary reconstruction for children and adults. Earlier innovations—including clean intermittent catheterization (CIC), bladder augmentation, and a variety of bladder neck tightening procedures—created the foundation that made continent bladder reconstruction possible. The technically difficult problem was creating a bladder outlet that was tight enough to ensure continence but wide enough to allow reliable catheterization over a lifetime. In addition, many of these patients have physical disabilities that prevent easy access to the urethra, making independent urethral catheterization challenging. The concept of a continent catheterizable abdominal channel was introduced by Paul Mitrofanoff in 1980 (1) and has since been widely adopted as an integral part of urinary tract reconstruction for continence in most pediatric centers worldwide. This principle involves creation of a flap-valve continence mechanism for a conduit that is tunneled into a low-pressure urinary reservoir that can then be catheterized and emptied via an abdominal stoma (Fig. 108.1).

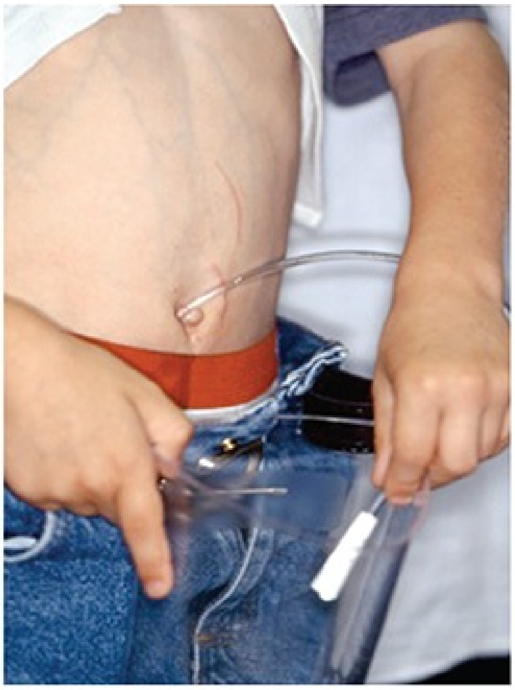

FIGURE 108.1 Umbilical Mitrofanoff stoma allowing catheterization in the sitting or standing position.

There are multiple surgical options for creating the Mitrofanoff channel. Appendicovesicostomy has by tradition been used because of availability, the reliable blood supply, adequate lumen for catheterization, and supple muscular wall. Long-term follow-up has shown that appendicovesicostomy provides a durable channel with minimal late complications (2,3). In the absence of a suitable appendix, or in conditions where the appendix is used for an alternate procedure (such as for a Malone antegrade continence enema [MACE channel]), there are several other options that have been described. The most reliable alternatives have been the Monti–Yang ileovesicostomy, ureterovesicostomy, and continent bladder tube.

Diagnosis

The Mitrofanoff procedure can be performed with essentially any underlying bladder pathology. The most frequent diagnosis for children undergoing the procedure is neuropathic bladder, usually due to myelomeningocele. This procedure has also been described for reconstruction in patients with exstrophy–epispadias, cloacal anomalies, prune belly syndrome, posterior urethral valves, and other conditions. Although many of these children will require a bladder outlet procedure to provide urinary continence, some will have an intact and continent bladder outlet and the Mitrofanoff channel will provide an alternative to urethral catheterization. This is especially useful in wheelchair-bound patients who cannot access their perineum independently and also in patients with normal urethral sensation, in whom catheterization can be traumatic both physically and psychologically.

Indications for Surgery

In the past, the primary indication for bladder reconstruction was for upper urinary tract preservation. In the era of aggressive use of anticholinergics and intermittent catheterization in young patients, the more common indication for a Mitrofanoff channel is for urinary continence and convenient, independent bladder management for the patient. All patients should undergo a trial of CIC to demonstrate that they are reliable and able to comply with a daily routine prior to bladder reconstruction.

Alternative Therapy

The most common alternative to continent bladder reconstruction with a Mitrofanoff stoma is anticholinergic therapy with clean intermittent urethral catheterization. With careful attention to catheterization schedules and fluid intake, social dryness can be achieved in many patients with neuropathic bladder and other underlying bladder pathology without the need for surgical intervention.

Less frequently used alternatives are long-term incontinent cutaneous vesicostomy, incontinent ileovesicostomy channel, and conduit urinary diversion. Although these are considered suboptimal in the era of continent urinary reconstruction, there will be a subset of patients who are unable to care for themselves because of physical, mental, or psychosocial problems, and the incontinent diversion provides a safer long-term option for these patients.

In the rare patient with a completely nonusable bladder, a continent urinary reservoir with a continent catheterizable channel is another alternative.

Surgical Technique

Many centers today have adopted outpatient oral mechanical bowel preparation with admission to the hospital the day of surgery. A urine culture should be obtained preoperatively and urinary tract infection treated. Perioperative intravenous antibiotics should be given for 24 hours. Potential sites for stomal location should be determined preoperatively, with the patient in the sitting and supine position.

Surgical exposure is usually obtained through a small lower midline transabdominal incision that, if needed, may be carried around the umbilicus to leave enough fascia to close the abdomen without compromising an umbilical stoma. A lower transverse Pfannenstiel incision will also allow adequate exposure for both bladder augmentation and the Mitrofanoff stoma in thin patients. Laparoscopy and robotic-assisted laparoscopic surgery has been used in some centers to either to assist in mobilization of the appendix and colon (allowing a smaller abdominal incision to complete the reconstruction without compromising exposure), or to complete the entire procedure, avoiding the larger abdominal incision. The robotic approach has the clear advantage over a pure laparoscopic approach of technically easier intracorporal sewing.

Appendicovesicostomy

The right colon is mobilized beyond the hepatic flexure to allow maximal freedom of the appendiceal mesentery. If the appendix is retrocecal in location, it is mobilized carefully from the cecal attachments with extra caution to avoid injuring the appendiceal artery, which is a branch of the ileocolic artery (Fig. 108.2). In some cases, there is significant peritoneal inflammation due to the presence of a ventriculoperitoneal shunt, and the peritoneal incision must be carried medial to the ileocecal valve to adequately mobilize the appendix. When the length of appendix is inadequate, it can be extended by incorporating a segment of distal cecum as described by Cromie et al. (4). Prior to detaching the appendix, the bladder is mobilized to ensure that the bladder and appendix can easily reach the chosen site for the abdominal stoma without tension. At our center, we now preferentially implant the Mitrofanoff channel in the anterior bladder wall, usually in an extravesical fashion, especially when performing the procedure without simultaneous bladder augmentation. This avoids a large cystotomy, decreasing bladder irritability postoperatively, and also allows improved fixation of the entire channel/bladder to the posterior abdominal wall. In cases where the bladder needs to be opened, the cystotomy is made to the left of the midline for a right lower quadrant appendicovesicostomy or in a wide inverted U-shaped anterior bladder incision for an umbilical stoma. The appendix is detached from the cecum either sharply or with a stapling device, and the cecum is closed with absorbable and permanent sutures. The mesentery to the appendiceal artery can be freed from the cecal mesentery to allow complete mobilization of the appendix if needed (Fig. 108.3). The terminal end of the appendix is then opened, and the channel is irrigated with antibiotic solution. A 12Fr to 14Fr catheter is passed to ensure that the appendix has an adequate lumen. If necessary, the appendix can be gently dilated with serial sounds. If bladder augmentation is to be performed, the segment of bowel is isolated, harvested, and reconfigured appropriately. If an additional segment of intestine is required for the Mitrofanoff (e.g., Monti–Yang) channel, it can be harvested simultaneously. The site of the bladder hiatus is then selected, again ensuring that it can easily reach the posterior abdominal wall fascia without tension. The site of the hiatus is opened wide enough to allow the appendix to pass without any tension, and a vessel loop is passed through the hiatus for traction. A submucosal bladder tunnel is then created using sharp dissection. Placing several traction sutures on the bladder to flatten out the posterior bladder wall facilitates this dissection. The orientation of the tunnel should be directed away from the bladder outlet and trigone to prevent painful catheterization postoperatively. The tunnel length should be at least 2.5 cm in length. It is occasionally helpful to inject 1:200,000 epinephrine along the path of the submucosal tunnel to facilitate the dissection and minimize bleeding. The terminal end of the appendix is then passed through the bladder hiatus and submucosal tunnel. The appendix is spatulated and secured distally with two 4-0 absorbable sutures incorporating full-thickness bites of the appendix and detrusor muscle and mucosa. The remainder of the anastomosis is completed using 4-0 or 5-0 absorbable sutures, securing the bladder mucosa to the appendix. The appendix is also secured at the level of the bladder hiatus using several 4-0 absorbable sutures. The channel is catheterized with a 12Fr or 14Fr catheter to ensure that it passes easily across the hiatus and submucosal tunnel. With an extravesical technique, the detrusor muscle is incised the entire length of the proposed tunnel (3 to 4 cm) using fine needle point cautery, and lateral detrusor flaps are raised using sharp dissection. A small incision is made in the mucosa at the distal end of the tunnel, and the appendix is secured with two 4-0 sutures to the mucosa and bladder muscle. The remainder of the anastomosis is carried out in a mucosa to mucosa fashion with either 4-0 or 5-0 suture. It is helpful to place a catheter across the anastomosis during the mucosal anastomosis. The detrusor flaps are then secured over the appendix with 3-0 interrupted absorbable sutures, with occasional bites that include both detrusor and serosa of the appendix. A right-angle clamp is placed periodically within the tunnel to ensure that the closure is not too tight. The appendix is secured at two sites at the detrusor hiatus. The stomal site is then selected, again taking care to ensure that the bladder hiatus can reach the posterior fascia without tension. A U-shaped (umbilical) or V-shaped skin incision is made at the stomal site, and the flap is freed sharply to the level of the fascia. A cruciate incision is made in the fascia and widened to allow passage of an index finger. The appendix is then brought through the fascial opening and the appendiceal/bladder hiatus is secured to the posterior fascial wall using 3-0 nonabsorbable sutures, taking care not to angulate or compress the appendiceal mesentery (Fig. 108.4). This maneuver ensures a short, straight extravesical appendix channel, which will minimize the potential for traumatic catheterization and creation of a false passage. With an extravesical implant technique on the anterior bladder wall, the detrusor closure sutures can also be used to fix the bladder to the posterior abdominal wall, further securing the closure and continence mechanism. The stomal end of the appendix is then spatulated on the antimesenteric side, and if there is redundant appendix, it is amputated. The stomal anastomosis is secured using interrupted 4-0 absorbable sutures (Fig. 108.5). The stoma is then catheterized multiple times with the bladder both distended and empty to ensure that there is no angulation in the channel. A 12Fr catheter is left indwelling for 3 to 4 weeks before initiating intermittent catheterization.

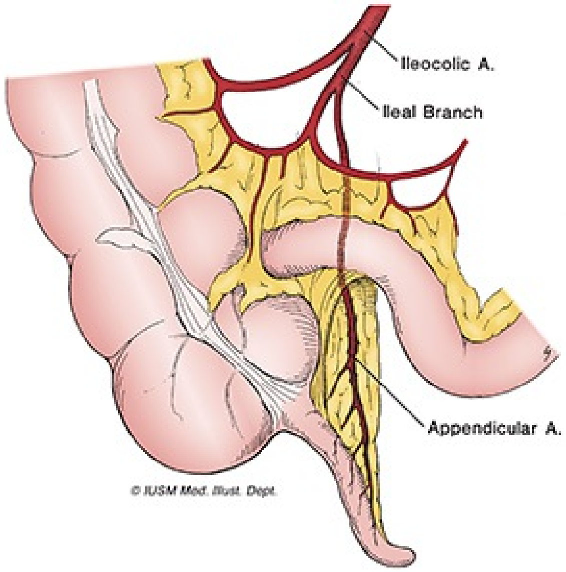

FIGURE 108.2 Vascular anatomy of appendicular artery.

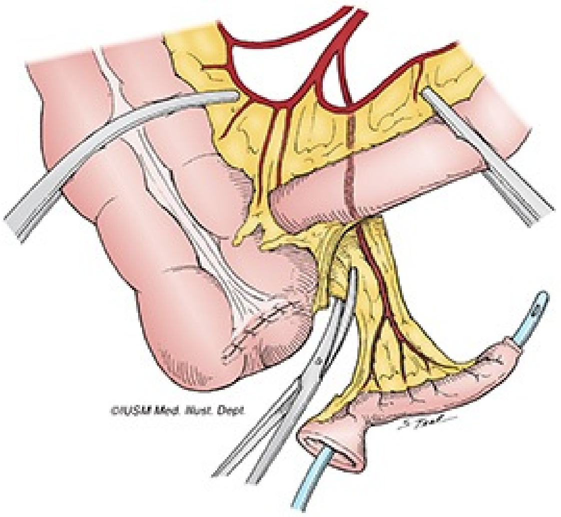

FIGURE 108.3 The mesentery to the appendix can be mobilized carefully, taking care not to injure the appendicular artery.

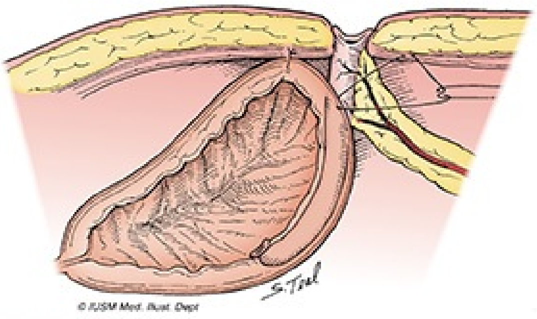

FIGURE 108.4 The bladder is secured to the posterior abdominal fascia to avoid redundancy in the extravesical channel, which can be a source of late catheterization problems.

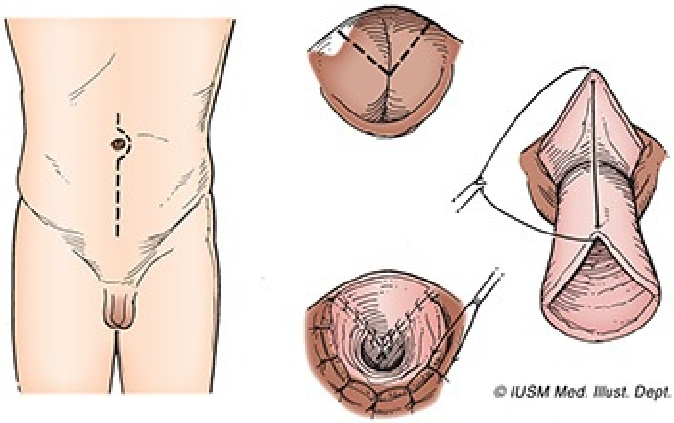

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FIGURE 108.5 The skin stoma is completed by securing the wide-based V flap of skin into the spatulated channel.

When both Mitrofanoff and MACE channels are indicated, and the appendix is of adequate length to create both channels, it can be split, with the majority of the mesoappendix left intact with the Mitrofanoff segment, basing the blood supply to the appendiceal stump off the cecal artery. In some cases, the appendix is too short to use for both channels, but in this circumstance, the appendix can still be used for both channels, utilizing one of the described stapling techniques to extend the proximal portion of the appendix into the cecum for the MACE channel (5,6).

Monti–Yang Ileovesicostomy

The concept of retubularized ileum as a replacement for the appendicovesicostomy was introduced in 1997 (7,8), and it has quickly become the ideal alternate to appendix as a choice for the Mitrofanoff channel. Several large series with intermediate follow-up have confirmed the equivalent outcomes for the Monti–Yang channel and appendicovesicostomy (9). The growing indications for and use of the MACE channel have led to preservation of the appendix for the appendicocecostomy stoma and the need for alternatives for a bladder channel. Because some of the children will also undergo bladder augmentation at the time of reconstruction, the Monti–Yang channel can be easily constructed from a segment of the bowel harvested for augmentation.

A 2.5- to 3-cm segment of intestine is harvested with a well-vascularized segment of mesentery (Fig. 108.6). If ileal augmentation is planned, the Monti–Yang segment can be easily harvested from the distal end of the segment with a shared mesentery. The ileal segment is opened on the antimesenteric side (Fig. 108.7). It can be opened slightly off the midline to provide a longer segment for implanting into the bladder. The opened segment is then retubularized transversely in two layers over a 14Fr catheter. The bowel mucosa is approximated with running 5-0 or 6-0 absorbable sutures and the muscular layer is closed with running or interrupted 4-0 absorbable sutures (Fig. 108.8A and B). The stomal end is not closed initially, providing wide spatulation of the antimesenteric side of the tube for later stomal anastomosis. The technique of implanting the tube into the bladder and creating a stoma is identical to that for appendicovesicostomy (Fig. 108.9). The Monti–Yang tube can be created out of any segment of intestine with good results. If there is inadequate bladder volume for creation of a submucosal tunnel, the tube can be implanted into a segment of bowel using an extravesical technique. Care must be taken to adequately secure the channel in the serosal tunnel. We have found that it is helpful to secure the entire tunnel length to the posterior fascial wall to prevent breakdown of the thin intestinal muscular backing during repetitive bladder filling due to effacement/breakdown of the serosal tunnel, which may be a potential cause for late incontinence. A 12Fr catheter is left across the channel for 3 to 4 weeks before initiating intermittent catheterization. The Monti channel can also be used for the MACE channel, with two channels created side by side (Fig. 108.10).

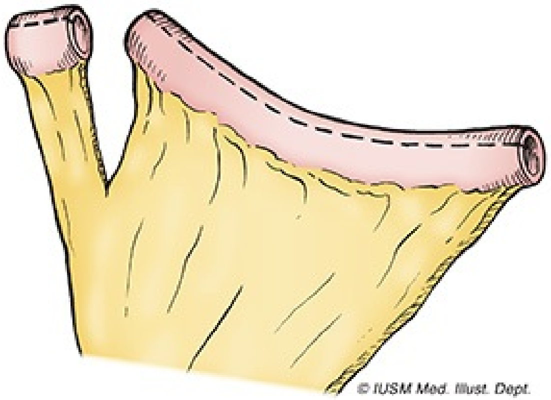

FIGURE 108.6 A 2.5- to 3-cm segment of ileum is harvested, distal to the segment of intestine to be used for augmentation (if indicated).

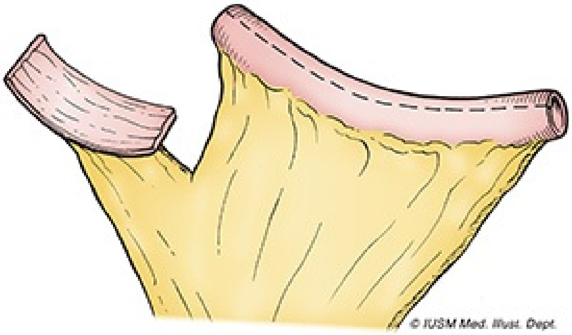

FIGURE 108.7 The Monti segment is detubularized on the antimesenteric side. This incision can be between the 9 and 12 o'clock positions depending on the desired length of intravesical tunnel.

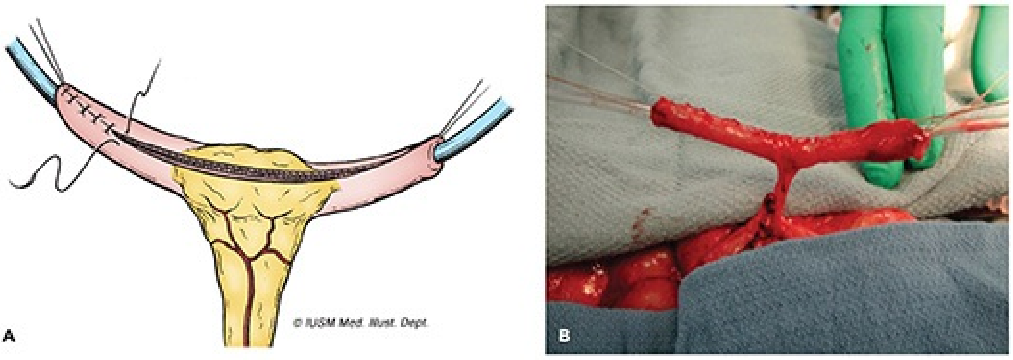

FIGURE 108.8 **A:** The channel is closed with two layers of absorbable sutures. The stomal end is either closed with interrupted sutures or not closed to allow adequate spatulation at the skin stoma. **B:** Operative photo of completed Monti channel.

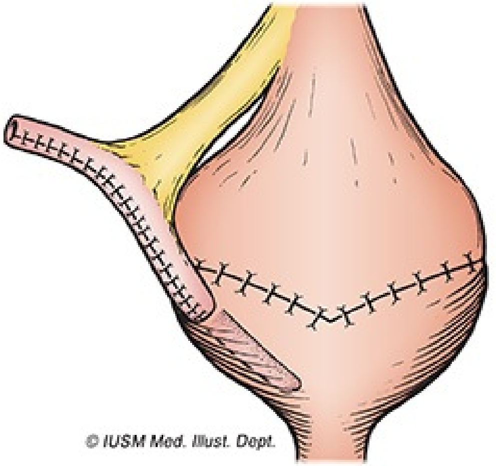

FIGURE 108.9 The Monti channel can be brought out either to a lower abdominal stoma or to the umbilicus. The mesentery is mobilized from the pedicle of the bladder augmentation to provide a tension-free skin anastomosis.

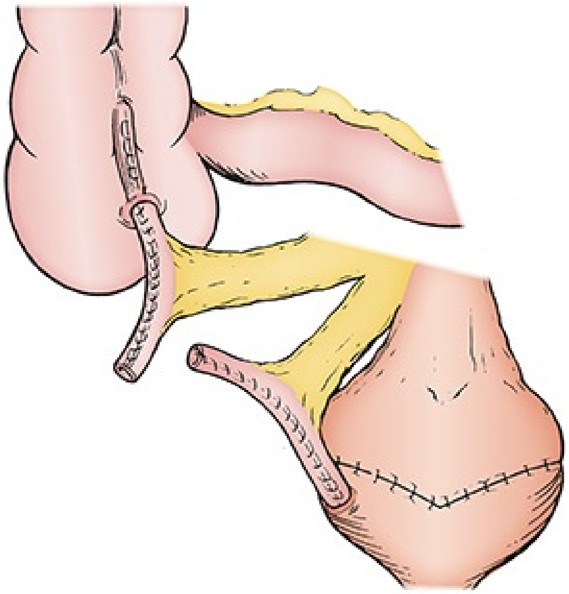

FIGURE 108.10 The “dual Monti,” utilizing a Monti channel for both the Malone antegrade continence enema and Mitrofanoff channels.

When the Monti channel does not provide adequate length for the extravesical section to reach the abdominal stomal site without tension, then two Monti tubes can be reconfigured and connected (the “double Monti”). This can provide a longer limb to reach the skin stoma but also introduces increased risk of postoperative complications of diverticulum, angulation, and perforation at the anastomosis of the two channels (10). To avoid this complication, Casale (11) described a long ileovesicostomy technique using a single piece of bowel to create a channel 10 to 14 cm in length. This technique uses a 3.5- to 4-cm segment of bowel that is isolated on its mesentery and divided into two equal segments for approximately 80% of the bowel circumference, leaving the two segments attached at the mesenteric side. The two loops of intestine are opened close to the mesentery on opposite sides, allowing the bowel to unfold in opposite directions, creating a long flat plate of intestine that can be retubularized after trimming the redundant lateral edges. Late follow-up has demonstrated good results for the Monti and Casale-Monti, with the exception of statistically significant higher open revision rates for the longer spiral Monti (Fig. 108.11) placed in the umbilicus, presumably due to extravesical channel elongation and tortuosity over time and development of a perihiatal diverticulum (Fig. 108.12) (12).

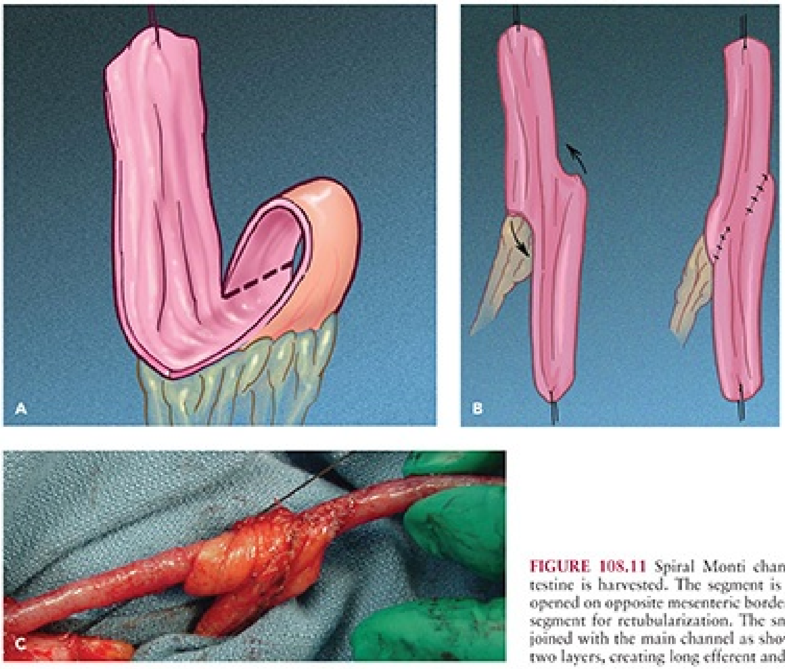

FIGURE 108.11 Spiral Monti channel. A: A 4-cm segment of intestine is harvested. The segment is divided in the middle and then opened on opposite mesenteric borders. B: This creates a 10- to 12-cm segment for retubularization. The small dog ears can be trimmed or joined with the main channel as shown. C: Channel retubularized in two layers, creating long efferent and afferent limb.

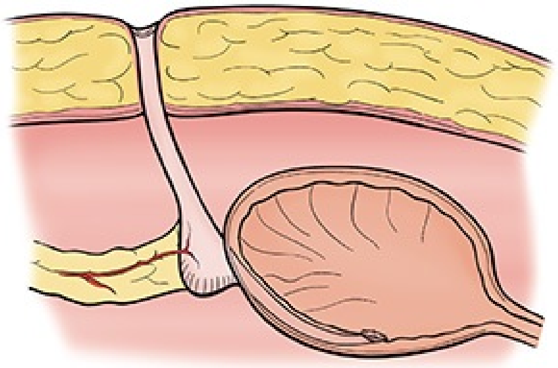

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FIGURE 108.12 Diverticula in channel directly outside the bladder hiatus. This complication occurs from repetitive difficult catheterization due to a long and tortuous extravesical portion of the Mitrofanoff channel.

Continent Vesicostomy

Small subsets of patients require creation of only a catheterizable bladder channel without bladder augmentation or other intra-abdominal procedures. These patients are good candidates for extraperitoneal continent vesicostomy. The largest reported experience is using the procedure described by Cain and Rink et al. (13) utilizing an intravesical submucosal-mucosal– lined tunnel to create the continence mechanism. This procedure has been successfully used with a variety of underlying bladder pathologies.

The bladder is opened to allow creation of either a midline or lateral full-thickness bladder flap (Fig. 108.13A). Mucosal incisions are extended intravesically, leaving a 2.5-cm plate of mucosa. The mucosa is sharply dissected off the underlying detrusor muscle laterally and medially to allow tension-free mucosal closure (Fig. 108.13B). The intra- and extravesical mucosal tube is created over a 14Fr catheter with running 6-0 absorbable suture (Fig. 108.13C). The detrusor muscle of the extravesical portion of the tube is then closed with 4-0 absorbable sutures (Fig. 108.13D). The continence mechanism is then created by closing the lateral edges of the bladder mucosa over the mucosal tube using running 5-0 absorbable suture (Fig. 108.13E). The stoma can be created in either the lower abdomen or umbilicus. An indwelling 12Fr catheter is left in place for 3 to 4 weeks.

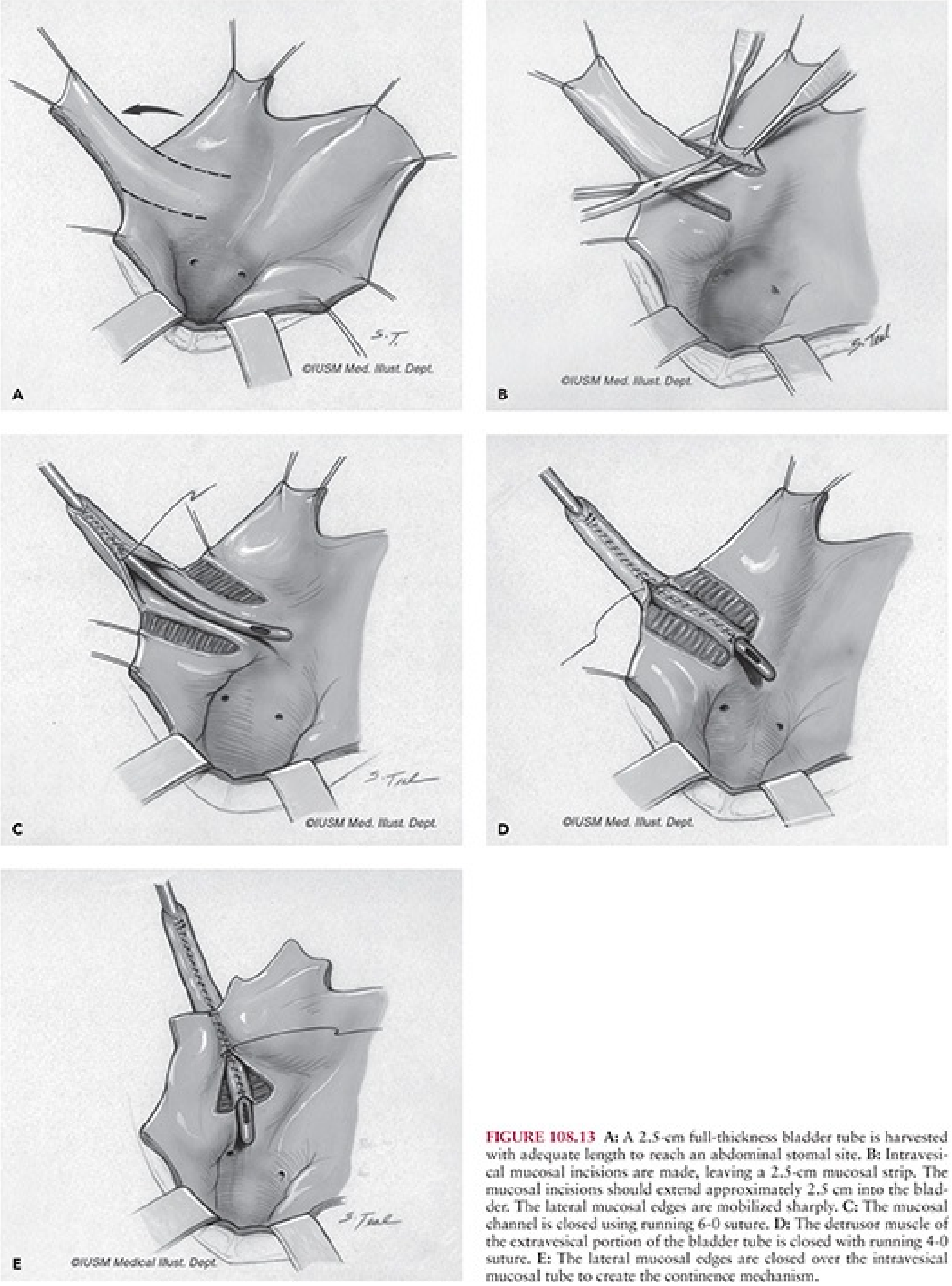

FIGURE 108.13 **A:** A 2.5-cm full-thickness bladder tube is harvested with adequate length to reach an abdominal stomal site. **B:** Intravesical mucosal incisions are made, leaving a 2.5-cm mucosal strip. The mucosal incisions should extend approximately 2.5 cm into the bladder. The lateral mucosal edges are mobilized sharply. **C:** The mucosal channel is closed using running 6-0 suture. **D:** The detrusor muscle of the extravesical portion of the bladder tube is closed with running 4-0 suture. **E:** The lateral mucosal edges are closed over the intravesical mucosal tube to create the continence mechanism.

Ureterovesicostomy

The ureter can be used as a catheterizable channel but has been less popular than bowel channels due to the additional upper urinary tract reconstruction required and the higher risk of skin stenosis and stomal leakage (14,15). When there is a unilateral nonfunctioning kidney with a nonrefluxing distal ureter, a ureteral channel should be considered, but this unfortunate situation should be avoidable in the present era of careful management of these patients from early in life. Several reports have also documented successful distal ureteral reimplantation at the time of the ureterovesicostomy. Obviously, careful mobilization of the ureter to prevent proximal and distal stenosis is an important technical factor.

Outcomes

Complications

Potential complications of the Mitrofanoff channel occur in approximately 20% to 25% of patients.

The common complications are listed in Table 108.1. The most frequent problem is stomal stenosis, occurring in 10% to 20% of channels in most series. The continent vesicostomy has a much higher rate of skin stenosis than either appendix or Monti–Yang channels, with as many as 50% requiring skin level revision. A short period of passive catheter dilation for 7 to 10 days will avoid the need for surgical intervention in some patients. If necessary, revision of the stoma with a well-vascularized flap of skin is usually successful to manage significant stenosis.

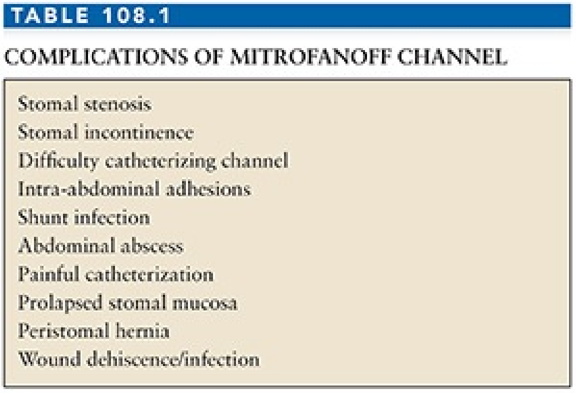

TABLE 108.1

COMPLICATIONS OF MITROFANOFF CHANNEL

Stomal stenosis
Stomal incontinence
Difficulty catheterizing channel
Intra-abdominal adhesions
Shunt infection
Abdominal abscess
Painful catheterization
Prolapsed stomal mucosa
Peristomal hernia
Wound dehiscence/infection

Difficulty catheterizing the channel can occur secondary to angulation, perforation/false passage, or stenosis of the channel. Initially, this should be treated conservatively with endoscopic placement of an indwelling catheter for 1 to 2 weeks. On occasion, reoperation will be necessary, and the patient and surgeon should be prepared to replace the entire tube if required. On a recent unpublished review of over 500 Mitrofanoff channels, our institution has identified a significantly higher risk of subfascial complications requiring major revision in the Monti and spiral Monti procedures compared to the appendicovesicostomy. This difference becomes evident with longer term follow-up and is felt to occur from chronic diverticular outpouching of the channel and chronic minor trauma during catheterization. Many of these channels can be salvaged with excision of the diverticulum, shortening of the extravesical portion of the channel, and resecuring the bladder hiatus to the posterior fascia.

Complications will usually occur within the first year but may occur many years after construction of a Mitrofanoff channel, and long-term follow-up with these patients is mandatory, especially when the Mitrofanoff channel is the sole means to empty the bladder (2,16).

Results

Most large series have reported long-term success in up to 96% to 98% of Mitrofanoff channels (2,17). Because appendicovesicostomy has been used since the initial description of the procedure, there are better long-term data for this specific procedure, which has been shown to be durable over long periods of intermittent catheterization. We recently reported our results using the Monti–Yang channel in 199 consecutive patients, achieving 97% success with an average of 3 years of follow-up, which was identical to our experience with appendicovesicostomy (9). Because of the short continence zone required with the mucosal flap-valve technique for continent vesicostomy, there has been nearly 100% success with this procedure with respect to stomal continence.

Failure to obtain continence can be due to an inadequate submucosal tunnel, a fistula into the Mitrofanoff tube, breakdown of the muscular backing to the submucosal tunnel (especially when implanted into a bowel segment), or poor bladder compliance/high intravesical pressure. In many instances, the underlying problem will be the bladder, and any patient with a failed Mitrofanoff should undergo repeat urodynamic studies of the bladder and a trial of anticholinergics. We have had good success with reimplanting a previously constructed channel at the time of secondary bladder augmentation when the initial Mitrofanoff channel has failed because of changing bladder dynamics.

MALONE ANTEGRADE CONTINENCE ENEMA PROCEDURE

The MACE procedure was introduced by Padraig Malone in 1990 (18), creating the final step for potentially achieving complete urinary and fecal continence. The majority of patients in a pediatric urology practice who would potentially benefit from this procedure are those with spina bifida with neuropathic bladder and bowel, or in patients with functional severe constipation related to their urinary tract disease. The greatest advantage for the MACE technique is providing the patient with poor physical mobility with independent access to the colon to allow antegrade colonic enema washouts either via the right or left colon, avoiding the need for oral laxatives/stool softeners or rectal enemas.

Indications for Surgery

The first step in patient selection is to essentially exhaust medical management for fecal incontinence and constipation. The greatest challenge for medical management in patients with neuropathic bowel is the underlying combination of slow colonic transit, reduced anal sphincter tone, reduced sensation, limited physical mobility/obesity, underlying chronic colon distention, and the added problem of constipating medications (e.g., oxybutynin) to control the associated neuropathic bladder disease. The result is often extremes ranging from controlled constipation to liquid stool accidents. Appropriate medical management should include a trial of aggressive bowel cleanout and daily management as outlined in Table 108.2. Success of medical management relies on maintaining an aggressive program with a multidisciplinary team with reported success of 69% in experienced centers (19). Before progressing to a MACE option, patients must also demonstrate the ability to sit on the toilet for an adequate duration of time to evacuate the colon, usually 30 to 45 minutes.

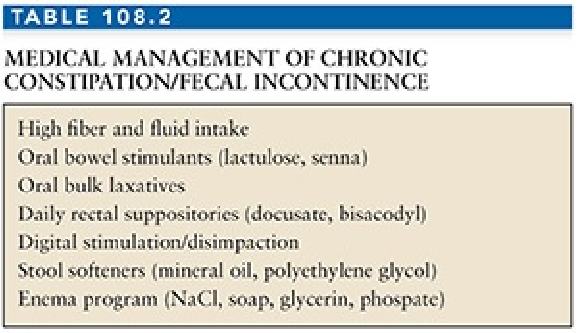

TABLE 108.2

MEDICAL MANAGEMENT OF CHRONIC CONSTIPATION/FECAL INCONTINENCE

High fiber and fluid intake
Oral bowel stimulants (lactulose, senna)
Oral bulk laxatives
Daily rectal suppositories (docusate, bisacodyl)
Digital stimulation/disimpaction
Stool softeners (mineral oil, polyethylene glycol)
Enema program (NaCl, soap, glycerin, phospate)

Alternative Therapy

The alternatives to surgically creating an antegrade enema channel all evolve around successful medical management, frequently involving a retrograde enema program which often requires either a cone enema device or the more recently used Peristeen irrigation system that creates occlusion of the incompetent rectal sphincter to allow high-volume enema infusion. These systems have equivalent outcomes for fecal continence obtained with the MACE technique but frequently require assistance in the less mobile patient. For patients who are poor candidates or wish to avoid major abdominal surgery, another option for the antegrade enema program is percutaneous placement of a cecostomy tube, such as the Chait tube. Results are identical to the MACE irrigation outcomes, but the obvious difference for the patient is an external appliance device. The final option for refractory fecal incontinence/constipation is colostomy, which is rarely needed with all the current available options.

Surgical Technique

Appendicocecostomy

The in situ appendicocecostomy is the most commonly used channel for the MACE procedure. Patients should all undergo preoperative mechanical bowel preparation, which can be accomplished with an outpatient regimen in the majority of patients. Intravenous broad-spectrum antibiotics are given perioperatively for 24 hours to avoid infection. When the MACE is done as an isolated procedure, it can be performed with either a pure open, laparoscopic assisted, or pure laparoscopic/robotic technique. For an open procedure, the abdomen is opened through a small infraumbilical incision. The appendix is identified, and adequate mobility and blood supply are determined by mobilizing the right colon to the hepatic flexure and freeing up the mesoappendix. The tip of the appendix is then amputated, and a 12Fr or 14Fr catheter is passed to insure patency of the appendix. The catheter is secured to the tip of the appendix, and catheter plug is placed to avoid contamination. Small windows are then made in the mesoappendix to allow cecoplication. The appendix is then intussuscepted into the cecum, securing the base of the appendix with several 4-0 nonabsorbable sutures. The appendix is positioned against one of the tenia, and cecoplication is accomplished by bringing the mobile portion of the cecum through the mesoappendix windows, securing it to the colon on the contralateral side of the appendix. Two 4-0 nonabsorbable sutures are placed at each mesenteric window, one of these catching small bites of the serosa of the appendix to fix the appendix in the tunnel. If possible, three to four total plications windows are created, and the cecum is secured to the distal end of the appendix at the terminal hiatus. The stomal site is then selected, and a U- or V-shaped flap is created at the skin level. The fascia is opened with a cruciate incision, and the appendix is brought through the fascia. The cecum is fixed to the posterior fascia at the level of the appendix hiatus with three nonabsorbable sutures to prevent angulation. Once the abdominal and skin incision is closed, the channel catheter is removed, and the appendix spatulated and anastomosed to the skin flaps with 4-0 absorbable suture. For an umbilical stoma, the author prefers a simple U-shaped incision that provides concealment of the stoma (Fig. 108.14). A 12Fr or 14Fr catheter is left indwelling for 3 to 4 weeks before catheterization is initiated. The MACE irrigations are usually started as soon as the patient begins oral feeds after surgery. At our institution, we will usually begin with low-volume (50 mL) flushes and increase the irrigation volume by 50 mL every 2 to 3 days until good results are obtained, which will usually require several weeks.

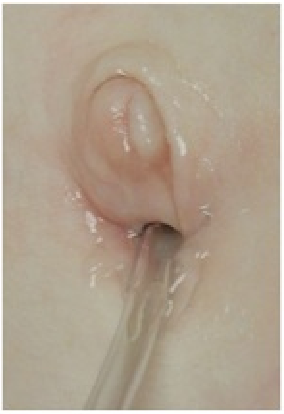

FIGURE 108.14 Umbilical MACE stoma.

Occasionally, the appendix will be of adequate length to be used for both a Mitrofanoff and MACE channel. In these patients, the distal 4 to 5 cm of appendix is separated, taking care to leave both segments with adequate mesenteric blood supply. If the proximal portion is too short for adequate plication, the appendix can be “extended” into the distal cecum using a stapling device as described by Sheldon et al. (6). The tubularized cecal segment can then be imbricated to create the continence mechanism.

In obese patients who would require a larger abdominal incision to mobilize the cecum, or for patients undergoing an isolated MACE procedure, a laparoscopic or laparoscopic-assisted procedure is very useful for intra-abdominal mobilization. For a pure laparoscopic procedure, the appendix can either be plicated or brought directly through the abdominal wall without any plication. Alternatively, the cecum and appendix can be mobilized laparoscopically, the inferior port site can be converted to a small 2- to 3-cm abdominal incision, and the cecum can be brought through the incision for extracorporal appendicocecoplication, and then brought back out through the umbilical port as a stomal site.

Monti–Malone Antegrade Continence Enema and Cecal Flap Malone Antegrade Continence Enema

When the appendix is either absent or not useable, there are still several surgical options for creating a catheterizable MACE channel. These techniques are especially useful when contemplating a left-sided MACE procedure, which in some reports has demonstrated equivalent results with faster washout times. The Monti-MACE tube is constructed as described previously for the bladder channel, using a 3-cm segment of bowel to create a neoappendix (Fig. 108.15A–D). This is then tunneled into a split-tenia channel on either the right or left colon. The serosa flaps on both sides of the tenia in0cision are mobilized and then secured over the Monti channel with nonabsorbable sutures, which can also be used to secure the entire tunnel to the posterior fascial wall to reinforce the continence mechanism and secure the channel.

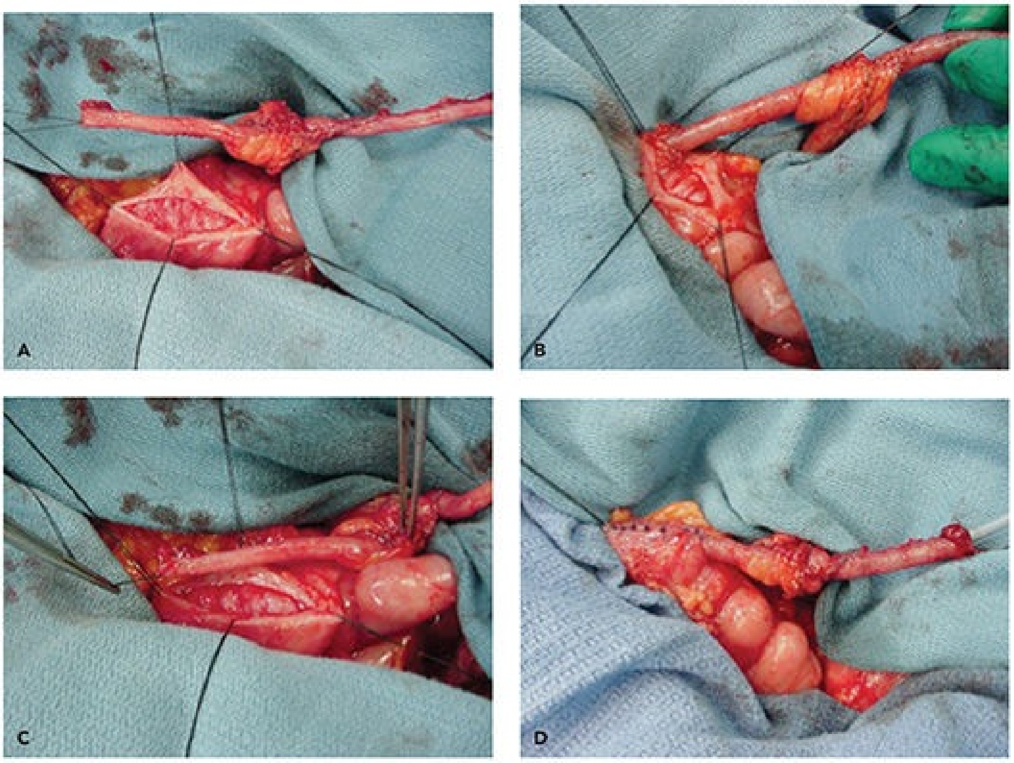

FIGURE 108.15 Monti-MACE. **A:** The Monti is constructed from a 3- to 4-cm segment of intestine. **B:** The serosa of the tenia of the colon segment is incised, and the channel is anastomosed to the bowel mucosa. **C:** Lateral tenia flaps are raised sharply to allow tension-free closure anterior to the MACE channel. **D:** The serosal flaps are closed over the channel up to the border of the mesentery. The channel is then secured to the bowel serosa.

The colon flap MACE relies on a medial based rectangular full-thickness cecal flap that is retubularized and buried in a seromuscular tunnel (20).

Outcomes

Complications

The MACE procedure has similar types of complications as seen with Mitrofanoff channels, including stomal stenosis, channel angulation/obliteration, traumatic false passage, and stomal incontinence. Stomal stenosis is the most frequently cited complication and is reported in 5% to 30% of patients (21,22). This is usually a fairly simple complication to manage, with just a simple skin revision or channel dilation. Several reports have demonstrated success at decreasing skin complications by leaving a small stent or ACE stopper across the stomal anastomosis for the first 6 months after surgery (23). In a sequential review of 280 MACE channels at our institution (22,24), we found that the in situ appendix was associated with the lowest overall complications, with a reoperation rate of 16%, compared to the Monti-MACE (18%), split appendix (21%), cecal flap (30%), and stapled cecal extension (33%). The majority of patients requiring surgical revision can be managed with a single procedure, although 30% require multiple interventions. The incidence of stomal incontinence is 3% to 4% but has been higher in nonplicated appendicocecostomy in multiple series.

Results

Patient satisfaction with the MACE procedure has overall been very positive, with several quality-of-life surveys demonstrating significant improvement in fecal incontinence and quality-of-life scores (25,26). The patients should be counseled preoperatively that the MACE irrigation requires significant time commitment, with flush times averaging from 30 to 45 minutes. The type of MACE irrigation recommended is quite variable, including normal saline or tap water to a variety of additives to either reduce transit time or reduce fecal soiling between irrigation. The average irrigation volume to reach success is also variable and is somewhat dependent on additives but will generally range from 200 to 1,000 mL. At our institution, we start flushes with tap water and add either mineral oil or polyethylene glycol to the irrigation for initial failures. Persistent incontinence is managed with the addition of oral polyethylene glycol and/or glycerine to the MACE flush. With this program, we have achieved a 94% success rate of less than one accident per month in patients who continue with the MACE program.

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INDEX

Page references followed by f or t indicate material in figures or tables, respectively.

A

Abdominal leak point pressure (ALPP), 178, 371, 404
Abdominal retropubic approaches, for female incontinence, 388–392
Abdominal sacral colpopexy, 431–433, 432f–433f
Abdominal wall, in prune belly (triad) syndrome, 763–770
Abdominoperineal approach, to rectourethral fistula, 209
Accessory glands, of male reproductive system, 446–448, 447f
Accessory scrotum, 905, 907
Acrolein, and hemorrhagic cystitis, 214
Adjustable male sling, 408
Adolescent rhabdomyosarcoma, 776–777
Adrenalectomy, laparoscopic, 87–95
    contraindications to, 88, 88t
    indications for, 88, 88t
    outcomes and complications of, 93–95
    preoperative considerations in, 89
    retroperitoneal, 89, 92, 93f–94f
    robotic, 89, 92–93, 94f
    single-site method of, 89
    surgical techniques in, 89–93
    transperitoneal, 89, 90–91, 90f–92f
Adrenal glands
    anatomic relationships of, 2, 2f
    anatomy of, 1–3, 1f–2f
    embryology of, 1–2
    structures contiguous to, 2–3
    vascular anatomy of, 2
Adrenal lesions
    alternative therapy for, 88–89
    cryoablation of, 88–89
    diagnosis of, 88, 89t
    laparoscopic adrenalectomy for, 87–95
    radiofrequency ablation of, 88–89
Adrenal tissue, ectopic, 2
Age-related penile hyposensitivity, 504
Al-Ghorab shunt, 607–608, 608f
Alum, for hemorrhagic cystitis, 215
Ambicor penile prosthesis, 612, 612f
Ambiguous genitalia, 886–894. *See also* Disorders of sexual development
American Medical Systems penile prostheses, 611–612, 611f, 611t, 612f, 613
American Urological Association (AUA), on LUS/BPO, 250–252, 251t

Amputation, traumatic
    penile, 636–641
    scrotal/testicular, 558–560, 560f
Anderson-Hynes dismembered pyeloplasty, 83–85, 83f, 85f, 86f
Andrews procedure, for hydrocele, 645–646, 646f
Anejaculation
    anorgasmia *vs.*, 503
    definition of, 503
    ejaculation induction for, 503–510
    nocturnal emissions and, 503
    primary, 503
    psychogenic, 503
    secondary, 503
Angioembolization
    for hemorrhagic cystitis, 216
    for intracaval tumors, 26
    for renal trauma, 97, 97f
Aniridia, isolated, 731
Anorgasmia, anejaculation *vs.*, 503
Anterior urethral valve, 825–826
Appendicocecostomy, 931, 931f
Appendicovesicostomy, 924–925, 924f–925f
Appendix, in continent catheterizable reservoir, 700, 700f, 703–705, 705f
Aquamid, 377
Arcus tendineus fasciae pelvis (ATFP), 421–422, 423f
Argus male sling, 408
Arteriogenic erectile dysfunction
    diagnosis of, 621–622, 621f
    vascular surgery for, 622–626
        outcomes and complications of, 624–626, 625f, 625t, 626f
        patient selection for, 622
        techniques in, 622–624, 623f–624f
Artificial erection, in hypospadias surgery, 828
Artificial urinary sphincter (AUS), 329, 393–403
    alternatives to, 394, 395t
    for children, 811
    contraindications to, 394
    control pump of, 393, 394f
    cuffs of, 393, 393f–394f
    indications for, 394
    male sling *vs.*, 394, 395t, 404–405, 409–410
    in men, 395–398
        bladder neck cuff placement for, 398
        inflatable penile prosthesis implantation with, 400
        male sling *vs.*, 409–410
        perineal cuff placement for, 395–397, 396f
        postprostatectomy, 404–405

        after prior failed sling, 402, 409
        after radiotherapy for prostate cancer, 402–403
        transcorporeal cuff placement for, 397, 397f, 398f
        transverse scrotal incision for placement of, 397–398, 398f–400f
    modifications and advances in, 393
    outcomes and complications of, 401–402, 401t–402t
    in pediatric population, bladder augmentation with, 400–401
    preoperative preparation for, 394–395
    pressure-regulating balloon of, 393
    surgical technique for, 394–395
    tandem cuff placement for, 401
    in women, 398–400, 400f
Asopa technique, in staged urethroplasty, 348, 348f
Atrial thrombus, intracaval tumor and, 33–34
Augmentation colocystoplasty, 178, 914–915, 916f, 920
Augmentation cystoplasty, 177–185
    alternatives to, 178
    bowel segment options in, 178
    complications of, 183–184
    history of, 177
    indications for, 177, 177t
    for interstitial cystitis/bladder pain syndrome, 219, 222, 223f
    outcomes of, 182–183
    patient assessment for, 177–178
    patient positioning for, 179, 179f
    pediatric, 910–922
        alternatives to, 911
        artificial urinary sphincter with, 400–401
        bowel segment for, 912, 913t
        complications of, 911, 912t, 920–921
        evaluation of anatomic and functional characteristics for, 911
        gastrocystoplasty in, 916–919, 918f
        gastrointestinal effects of, 920
        goal of, 910
        ileocystoplasty in, 913–914, 914f–916f
        indications for, 911
        intraoperative preparation of patient in, 912
        metabolic effects of, 920
        outcomes of, 921–922
        postoperative follow-up in, 920
        preoperative bowel preparation for, 911–912, 912t
        preoperative counseling on, 911
        preparation of bladder in, 912–913, 913f
        right colocystoplasty and Mainz enterocystoplasty in, 914–915, 916f
        sigmoidocystoplasty in, 915–916, 917f
        sphincteric incontinence surgery with, 911
        surgical techniques in, 911–919

        - ureterocystoplasty in, 919, 919f
        - urinary and abdominal drainage following, 919
        - vesicoureteral reflux surgery with, 911
    - postoperative care in, 183t
    - pre- and postoperative investigation regimen in, 182, 183t
    - pregnancy and, 184
    - principles of, 178
    - special circumstances in, 184
    - surgical technique in, 178–182, 179f–182f
- Augmentation gastrocystoplasty, 178, 916–919, 918f
- Augmentation ileocystoplasty, 178–184, 913–914, 914f–916f, 920
- Augmentation ureterocystoplasty, 919, 919f
- AUS. *See* Artificial urinary sphincter
- Autosomal dominant polycystic kidney disease (ADPKD), 70–71
- Azoospermia
    - definition of, 516
    - ejaculatory duct obstruction and, 456
    - nonobstructive, 516
    - obstructive, 516
    - sperm retrieval techniques in, 516–521
    - vasectomy and, 460–468
    - vasoepididymostomy and, 480–488
    - vasovasostomy and, 469–481

B

- Bacille Calmette-Guérin (BCG)
    - for interstitial cystitis/bladder pain syndrome, 220
    - for prostate urothelial carcinoma, 362
- Back-table preparation, of renal autograft, 122, 122f
- Balanitis xerotica obliterans, 577, 578f, 896
- Balanoposthitis, circumcision in, 896
- Barry shunt, 609
- Beckwith–Wiedemann syndrome, 731
- Bell clapper deformity, 547–548, 548f
- Benign prostatic hyperplasia (BPH), 250. *See also* Benign prostatic obstruction
- Benign prostatic obstruction (BPO), 250–269
    - basic management of, 250, 251f
    - bipolar transurethral resection of the prostate for, 255–256
    - botulinum toxin for, 265–266
    - conservative and medical therapy for, 252
    - diagnosis of, 250–252, 252t
    - electrosurgery for, 253–256
    - endoscopic complications in, 267
    - endoscopic transurethral surgical treatments for, 253–260, 267
    - investigational surgical procedures for, 264–266
    - laparoscopic or robot-assisted procedures for, 263–264
    - laser surgery for, 256–260

  - minimally invasive therapy for, 252–253
  - monopolar transurethral resection of the prostate for, 253–255, 255t
  - open surgery (prostatectomy) for, 260–263
    - retropubic, 261–262, 262f–263f
    - suprapubic, 260–261, 261f–262f
  - prostate size for recommended therapies in, 266t
  - prostatic urethral lift for, 264–265, 264f–265f
  - quality of life in, 250, 266
  - surgical complications in, 267
  - surgical indications in, 252, 254t
  - surgical techniques for, 252–266
  - transurethral incision of the prostate for, 253–255, 255t
  - transurethral microwave thermotherapy for, 252
  - transurethral needle ablation for, 252–253
  - treatment algorithm for, 252, 253f, 254f
  - treatment outcomes in, 266, 266t

Bifid scrotum, 905, 906

Biopsy
  - paracollicular/bladder neck, 668
  - prostate, 302–305, 303f–304f
  - renal, 73–74, 74f
  - sentinel node, in penile cancer, 585–586, 585f–586f, 591
  - testicular, 517–520, 518f

Bipolar transurethral resection of the prostate (B-TURP), 255–256

Bladder. *See also specific disorders and procedures*
  - anatomy of, 138–145
  - blood supply of, 141, 142f
  - contiguous structures of, 145
  - general description of, 138
  - histologic structure of, 139–140, 140f
  - hypertrophy, in prune belly (triad) syndrome, 763–770
  - ligamentous attachments of, 139, 139f
  - lymphatics of, 145
  - micturition reflex and, 143, 143f–144f
  - motor innervation of, 142–143
  - peritoneal relationships of, 138, 138f
  - sacral neuromodulation and, 144–145
  - sensory innervation of, 142
  - storage reflex and, 143–144

Bladder augmentation. *See* Augmentation cystoplasty

Bladder autoaugmentation, 178

Bladder cancer. *See also specific types*
  - kidney-sparing therapy for, 187
  - laparoscopic radical cystectomy for, 230
  - lymphadenectomy in
    - extended and superextended, 155, 156f, 235, 235f, 236f
    - in men, 152–153, 152f–153f, 155, 156f

        - with nephroureterectomy, 186, 186f
        - outcomes of, 239–240
    - nephroureterectomy for, 185–193
    - partial cystectomy for, 148–150
    - radical cystectomy in men for, 151–161, 233–234
    - radical cystectomy in women for, 161–171, 234–235
    - robot-assisted radical cystectomy for, 169–170, 230–242
    - urinary diversion for, 236–238, 236f–238f
- Bladder cuff technique
    - for artificial urinary sphincter, in men, 398
    - for laparoscopic nephroureterectomy, 64–66, 65f, 188–189, 189f
    - for open nephroureterectomy, 187–188
- Bladder denervation, 227, 228
- Bladder diverticula
    - definition of, 171, 242
    - diagnosis of, 172, 173f
    - location of, 171–172, 172f
    - surgical management of, 172–176, 242–243 (*See also* Bladder diverticulectomy)
- Bladder diverticulectomy, 171–176
    - alternatives to, 173
    - combined intravesical and extravesical, 174–175, 176f
    - complications of, 175–176
    - extravesical, 174, 242
    - indications for, 172–173
    - intravesical or transvesical, 174, 175f
    - open, 173, 174–175
    - outcomes of, 175–176
    - preoperative assessment for, 173
    - robotic, 242–243
    - transurethral resection in, 173–174
- Bladder entrapment, in pelvic fracture, 212, 213f
- Bladder exstrophy. *See* Exstrophy, *See* bladder
- Bladder hemorrhage, 214–216. *See also* Hemorrhagic cystitis
- Bladder hydrodistention, 221, 221f–222f, 227–228, 228t
- Bladder neck closure (BNC), 329–335
    - in female patients, 329–334
        - abdominal approach in, 331–334, 333f
        - vaginal approach in, 330–334, 331f–333f
    - indications for, 329–330
    - in male patients, 330, 334
        - abdominal closure in, 334, 334f
        - perineal approach in, 334
    - outcomes and complications of, 335
    - postoperative care in, 334–335
    - preoperative workup for, 330
    - surgical technique in, 330–334
- Bladder neck contracture, with rectourethral fistula, 205

Bladder neck reconstruction
    in bladder exstrophy, 852–853, 852f
    in children, 810–818
        fascial sling or bladder neck suspension for, 812–813, 812f
        indications for, 811
        Kropp urethral lengthening procedure for, 814–816, 815f
        minimally invasive, 817
        outcomes and complications of, 817–818
        Pippi Salle urethral lengthening procedure for, 816–817, 816f
        surgical options in, 811–812
        surgical technique of, 812–817
        Young–Dees–Leadbetter technique of, 813–814, 813f–814f
    in open radical retropubic prostatectomy, 274–275, 275f
    in radical perineal prostatectomy, 282–283, 282f
Bladder neck sling (BNS), 379–382
    abdominal incision for, 381
    adjusting tension of, 382, 382f
    for children, 812–813, 812f
    cystoscopy of, 381
    fascial harvest for, 381, 381f
    outcomes and complications of, 386–387
    suture passer advancement for, 381, 381f
    vaginal dissection for, 381
    wound closure for, 382, 382f
Bladder pain syndrome. *See* Interstitial cystitis/*See* bladder pain syndrome
Bladder perforation, augmentation cystoplasty and, 184, 920–921
Bladder rhabdomyosarcoma, 772–773, 773f, 775, 776f, 779, 780f
Bladder trauma, 210–214
    classification of, 210, 211t
    clinical presentation of, 210
    diagnosis of, 210
    etiology of, 210
    extraperitoneal, 210, 211f
    Foley catheter decompression for, 211, 212
    imaging of, 210, 211f
    intraperitoneal, 210, 211f
    management of, 211–213
    surgical repair of, 211–213
        complications of, 214
        extraperitoneal, 213
        indications for, 212
        postoperative care in, 213–214
        transabdominal, 212–213, 213f
    vaginal laceration with, 211
Bladder trigone, 141, 141f
Bloom syndrome, 731
Bosniak classification, of renal cysts, 69, 70t, 71f

Bottom-up retropubic midurethral sling, 384–385
Botulinum toxin
    for benign prostatic obstruction, 265–266
    for overactive bladder, 178
Bowel segment
    for augmentation cystoplasty, 178–184, 912, 913t
    for continent catheterizable reservoir, 697–698
    for ileal conduit urinary diversion, 657, 657f
    for orthotopic bladder substitution, 669–670, 670f, 675, 675f, 684, 684f, 688–689
    for transverse colonic conduit, 662, 662f
    transverse retubularized colon, 729, 729f
BPH. *See* Benign prostatic obstruction
BPO. *See* Benign prostatic obstruction
Brachytherapy
    definition of, 291
    for localized prostate cancer, 291–300
        advantages of, 291–292
        alternatives to, 292–293
        high-dose-rate, 296–298, 297t
        hybrid approach with real-time planning and linked seeds in, 295–296, 296f
        isotopes for, 292, 293, 293t, 296–297
        low-dose-rate, 293–296
        outcomes and complications of, 298–299, 298t, 299t
        patient selection for, 292, 292t
        postimplant dosimetry in, 296
        postimplant visualization in, 296, 296f
        posttreatment care in, 297–298
        preplanning approach in, 293, 293f
        real-time intraoperative planning approach in, 293–295, 293f–295f
Bracka buccal two-stage hypospadias repair, 833, 834f
Bricker ileal conduit, 238, 658–659, 659f
Broad ligaments, 421
Buck fascia, 554, 568–569, 568f
Bulbar urethral trauma, 353–356, 355f
Bulb of penis, 567, 567f
Bulbourethral glands, 444f, 447–448, 447f
Bulkamid, 377
Bulking agents
    for bladder neck, 811
    for female incontinence, 371–379
    for vesicoureteral reflux, 784, 798
Burch urethropexy, 388–392
    alternatives to, 389
    indications for, 389
    laparoscopic, 391
    open, 389–391, 390f
    outcomes and complications of, 391

Burns, scrotal, 554, 555–556, 556f, 562–563, 563f
Busulfan, and hemorrhagic cystitis, 214
Buttonhole technique, for transverse colonic conduit, 663, 663f

C

Calcium hydroxyapatite, urethral injection of, 376
Calculus disease
    augmentation cystoplasty and, 183, 921–922
    diagnosis of, 130
    in horseshoe kidney, 744
    laparoscopic management of, 130–132
        alternatives to, 130
        complications of, 132
        indications for, 130
        postoperative care in, 131–132
        surgical technique in, 130–131, 131f
    lower stones, 130–131
    upper stones, 130–131, 131f
Cantwell–Ransley epispadias repair, 850–851, 851f
Capsaicin, for interstitial cystitis/bladder pain syndrome, 220
Cardinal ligaments, 421, 421f
Cardiopulmonary bypass, in intracaval tumor surgery, 33–34, 33f–34f
Castration
    medical, 521, 522
    surgical (*See* Orchiectomy)
Cecal flap Malone antegrade continence enema, 931–932
Chemical burns, scrotal, 563
Chemotherapy, hemorrhagic cystitis induced by, 214
Chevron incision, in radical nephrectomy, 17f, 22–23, 23f
Chordee
    with hypospadias, 826–835, 827, 833–834, 834f
    without hypospadias, 650–655
Circumcision, 895–901
    alternatives to, 896–897
    American Academy of Pediatrics on, 895
    contraindications to, 895, 895f, 902
    epidemiology of, 895
    Gomco clamp for, 898, 899f
    HIV prevention in, 895
    indications for, 895–896
    misguided ideas and practices in, 895–896
    Mogen clamp for, 898, 901f
    neonatal, 898
    outcomes and complications of, 899–901, 901f
    penile cancer diagnosis and treatment in, 578
    penile cancer prevention in, 576, 895
    Plastibell for, 898, 900f, 901f

  - surgical technique in, 897–898, 897f–901f
  - timing of, 898–899

Clitoroplasty
  - outcomes of, 883
  - technique of, 879–880, 879f–880f, 889, 889f–890f

Cloacal anomalies, 877–885, 877f
  - decompression therapy for, 878–879, 882
  - diagnosis of, 878
  - outcomes of, 883–885
  - surgical indications in, 878
  - surgical technique for, 881–883, 882f–883f

Coaptite, 376

Coccygeus muscle, 422

Cohen repair, of VUR, 788–789, 789f

Colocystoplasty, augmentation, 178, 914–915, 916f, 920

Colonic conduit
  - sigmoid, 726
  - transverse colon, 661–666, 726
    - contraindications to, 661
    - indications for, 661
    - patient preparation for, 661
    - preoperative examinations for, 661

Colonic continent catheterizable reservoir, 702–715
  - alternatives to, 702
  - alternative techniques in, 705, 706f–708f
  - colon pouch (Mainz pouch III), 710, 711f, 712f
  - continence mechanism in, 713–714, 714f–715f
  - full-thickness tube for, 705, 706f
  - ileocecal pouch (Mainz pouch I) for, 703–705, 703f–705f, 708f
  - Indiana pouch for, 706–708, 710f
  - indications for, 702
  - intussuscepted ileal nipple in, 703, 703f, 713–714, 714f–715f
  - Mitrofanoff principle for, 702
  - outcomes and complications of, 710–715
  - seromuscular tube for, 705, 706f
  - surgical technique for, 702–714
  - Tiflis pouch for, 706, 708f
  - troubleshooting for, 713–714, 713f–715f
  - ureterointestinal strictures with, 713, 713f–714f
  - Yang–Monti technique in, 706f

Colonic orthotopic bladder substitution, 688–697
  - alternatives to, 689
  - blood supply in, 693, 695f
  - construction of reservoir in, 689–693, 690f–694f, 696f
  - indications for, 689
  - outcomes and complications of, 696–697
  - preoperative preparation for, 689

    rationale for, 688
    surgical technique for, 689–695
    ureteral implantation in, 695
Colon pouch (Mainz pouch III), 710, 711f, 712f
Colon segment, transverse retubularized, 729, 729f
Coloplast penile prostheses, 611, 611f, 611t, 612f
Colovesical fistulas, 202. *See also* Intestinovesical fistulas
Colpocleisis, 424
Colpopexy
    laparoscopic sacral, 433, 433f
    open sacral, 431–433, 432f–433f
Colporrhaphy
    anterior, 434, 435f
    posterior, 434–436, 436f–437f
Concealed penis, 895, 901–904, 902f
    inner skin as accessory coverage in, 902–903
    inner skin as primary coverage in, 902
    outcomes and complications in, 904
    scrotal anomalies with, 905
    surgical repair of, 902–903, 903f–904f
Congenital adrenal hyperplasia (CAH), 878, 886. *See also* Disorders of sexual development
Congenital bilateral absence of vas deferens (CBAVD), 443
Congenital curvature of penis, 650–655
    classification of, 650, 650f
    diagnosis of, 651, 651f
    incision and plication for, 651–654, 652f–654f
    multiple parallel plication for, 654–655
    outcomes and complications of, 655
    penile disassembly for, 655
    surgical indications in, 651
    surgical technique for, 651–655
    Yachia longitudinal plication for, 654, 654f
Constipation
    Malone antegrade continence enema for, 178, 181, 930–933
    medical management of, 930–931, 930t
Contigen (GAX-collagen), 373, 374–375
Continent catheterizable reservoir
    appendix as stoma in, 700, 700f, 703–705, 705f
    colonic, 702–715
        alternatives to, 702
        alternative techniques in, 705, 706f–708f
        colon pouch (Mainz pouch III), 710, 711f, 712f
        continence mechanism in, 713–714, 714f–715f
        full-thickness tube for, 705, 706f
        ileocecal pouch (Mainz pouch I) for, 703–705, 703f–705f, 708f
        Indiana pouch for, 706–708, 710f
        indications for, 702

    - intussuscepted ileal nipple in, 703, 703f, 713–714, 714f–715f
    - outcomes and complications of, 710–715
    - seromuscular tube for, 705, 706f
    - surgical technique for, 702–714
    - Tiflis pouch for, 706, 708f
    - troubleshooting for, 713–714, 713f–715f
    - ureterointestinal strictures with, 713, 713f–714f
    - Yang–Monti technique in, 706f
  - ileal, 697–701
    - alternatives to, 698
    - indications for, 698
    - outcomes and complications of, 701
    - patient selection and evaluation for, 698
    - postoperative care of, 701
    - preoperative preparation for, 698
    - surgical technique for, 698–700, 699f–700f
  - Mitrofanoff principle/procedure for, 702, 923–930
- Continuous bladder irrigation, for hemorrhagic cystitis, 215
- Corpora cavernosa
  - anatomy of, 567–569, 567f, 568f
  - decompression, in priapism, 606–607
- Corporal cannulation, for priapism, 608
- Corporo-deep dorsal vein shunt, 609
- Corporoglanular shunts, 607–608, 608f
- Corporoplasty, for Peyronie disease, 598
- Corporoplication, for Peyronie disease, 598
- Corporo-saphenous vein shunt, 609
- Corporospongiosal shunts, 608–609
- Corpus spongiosum, 567–570, 567f, 568f
- Costovertebral ligaments, 3, 4f
- Cowper glands, 444f, 447–448, 447f
- Cremasteric reflex, 521
- Crossed renal ectopic, 738, 739f–740f
- Cross-trigonal repair, of VUR, 788–789, 789f
- Cryotherapy
  - for adrenal lesions, 88–89
  - laparoscopic, for small renal masses, 76–81
    - outcomes and complications of, 79–80, 80t
    - postoperative care in, 79
    - surgical technique in, 79, 79f
  - for penile cancer, 579
  - for prostate cancer, 306
  - for renal tumors, 7
- Cryptorchidism, 854–864
  - blind-ending testicular vessels in, 857, 857f
  - cord structures entering inguinal ring in, 857–858, 857f
  - definition of, 854

    diagnosis of, 855–856
    diagnostic laparoscopy for, 856–858, 857f
    hormonal therapy for, 856
    inguinal orchiopexy for, 855f, 861–863, 862f–863f
    intra-abdominal, 854–855, 858–861, 858f
    in prune belly (triad) syndrome, 763–770, 765, 768–769
    scrotal orchiopexy for, 863–864
    single-stage laparoscopic orchiopexy for, 858–861, 859f–861f
    surgical management of
        alternatives to, 856
        anatomic considerations in, 854, 855f
        indications for, 856
        outcomes and complications of, 864, 864f
        techniques of, 856–864
    testis location in, 854–855
    two-stage Fowler–Stephens procedure for, 861, 861f
Culdoplasty
    Halban, 432, 432f
    McCall, 429, 430f
Curvature of penis. *See* Penile curvature
Cut-back vaginoplasty, 880
Cyanoacrylic glue, for vesicovaginal fistula, 195
Cyclophosphamide, and hemorrhagic cystitis, 214
Cystectomy
    for hemorrhagic cystitis, 216
    partial, 148–150
        alternatives to, 149
        extraperitoneal, 149–150, 149f–150f
        indications for, 148–149
        for interstitial cystitis/bladder pain syndrome, 222–224, 224f
        intraperitoneal, 150
        outcomes and complications of, 150
        for rhabdomyosarcoma, 775
        surgical technique in, 149–150, 149f–150f
        urachal excision with, 242
    radical, in men, 151–161
        alternatives to, 151
        anesthesia and instrumentation for, 152
        cystoprostatectomy in, 153–159, 153f–159f
        indications for, 151
        initial exposure in, 152
        lymphadenectomy in, 152–153, 152f–153f, 155, 156f
        outcomes and complications of, 160
        patient positioning for, 152
        patient preparation for, 151–152
        postoperative care in, 159–160
        prostate-sparing, 159

    radical cystoprostatectomy with nerve sparing in, 159
    radical cystoprostatectomy with orthotopic bladder substitution in, 158, 159f
    surgical technique in, 151–160
    urethral cancer recurrence after, 364
  radical, in rhabdomyosarcoma, 775
  radical, in women, 161–171
    age and medical comorbidities in, 163
    alternatives to, 162
    anatomic considerations in, 163–164
    anterior exenteration in, 161, 164–166, 164f–166f
    challenges and concerns in, 161
    complications of, 170
    “early,” 161
    extent of, paradigm for, 162, 163t
    female continence and, 163–164
    female sexual function and, 164
    functional outcomes and quality of life measures in, 163
    indications for, 161–162
    intractable local symptoms and, 162
    in muscle-invasive disease, 161–162
    in non–muscle-invasive disease, 162
    outcomes of, 170
    postoperative care in, 170
    preoperative care in, 162–163
    preoperative considerations in, 162
    reproductive organ preservation in, 168–169, 169f
    retrograde dissection and urethral-sparing technique in, 169, 169f
    robotic, 169–170
    surgical technique in, 163–170
    urethrectomy in, 167, 167f
    vaginal reconstruction in, 168, 168f
  radical, robot-assisted, 230–242
    alternatives to, 230–231
    anatomic orientation in, 231
    anterior dissection in, 233
    complications of, 240–241
    costs of, 241
    Enhanced Recovery after Surgery protocol in, 231, 231t
    functional outcomes of, 240
    indications for, 230
    lateral dissection of bladder and control of vascular pedicles in, 232–233, 233f
    learning curve in, 241
    lymphadenectomy in, 235, 235f–236f, 239–240
    in men, nerve-sparing modifications in, 233–234
    mobilization and division of ureters in, 231
    oncologic outcomes of, 238–240
    patient positioning and port placement in, 231, 232f

        postoperative care in, 238
        preoperative preparation for, 231
        quality of life after, 241
        retrovesical dissection in, 231–232, 232f
        specimen entrapment in, 233
        surgical margins in, 239
        transection of dorsal vein complex and membranous urethra in, 233
        urinary diversion in, 236–238, 236f–238f, 240
        in women, 234–235, 234f
    renal laparoscopic, 69–73
        decortication in, 70–72, 72f
        prevention of port-site metastases in, 72–73, 73t
        retroperitoneal approach in, 71–72, 72f, 74
        surgical technique in, 74
        transperitoneal approach in, 72, 72f
    simple, 146–148
        alternatives to, 146
        complications of, 148
        in female patients, 147–148
        indications for, 146
        intraperitoneal approach in, 146
        in male patients, 147, 147f–148f
        outcomes of, 148
        patient positioning for, 146–147
        surgical technique in, 146–148, 147f–148f
    total, for interstitial cystitis/bladder pain syndrome, 224
Cystitis. *See also specific types*
    hemorrhagic, 214–216
    interstitial, 217–230
Cystoplasty
    augmentation (*See* Augmentation cystoplasty)
    reduction, in prune belly (triad) syndrome, 765, 767, 767f
    substitution, for interstitial cystitis/bladder pain syndrome, 222–224, 224f
Cystoprostatectomy, 153–159
    one-stage, 155–158, 157f–158f
    radical
        with nerve sparing, 159
        with orthotopic bladder substitution, 158, 159f
    for rhabdomyosarcoma, 775, 776f
    surgical technique in, 153–154, 153f–159f
Cystorrhaphy, 211–213, 212f

D

Dartos fascia, 568–569, 568f
Dartos layer of scrotum, 572
Delayed ejaculation, 503–508
    definition of, 503

    - electroejaculation for, 506–508, 506f–507f, 507t
    - evaluation of, 503–504, 504f
    - medical treatment for, 504–505
    - penile vibratory stimulation for, 505–506, 505f
- Denys–Drash syndrome, 731
- Detrusor external sphincter dyssynergia (DESD), 328–329
- Detrusor muscle, 138, 143
- Detrusor myomectomy, 178
- Dimethyl sulfoxide (DMSO), for interstitial cystitis/bladder pain syndrome, 220
- Direct infusion cavernosometry and cavernosography (DICC), 622
- Direct vision internal urethrotomy (DVIU), 338, 340–341, 340f, 342–343
- Dismembered technique, in pyeloplasty, 742, 743f, 746–748, 747f, 754–756, 754f–756f
- Disorders of sexual development (DSD)
    - categories of, 886
    - clitoroplasty for, 889, 889f–890f
    - diagnosis of, 887, 887f
    - family issues in, 887–888
    - labioplasty for, 890–891, 890f
    - nomenclature for, 886
    - surgical management of, 886–894
        - controversy and concern over, 878, 886
        - external genitalia repair in, 889–891
        - history of, 886
        - outcomes and complications of, 894
        - patient positioning for, 888–889
        - preoperative evaluation for, 888, 888f
        - techniques in, 889–894
        - timing of, 888
    - team approach to, 887
    - total urogenital mobilization for, 891–894, 892f–893f
    - urogenital sinus anomalies in, 877–878, 891–894, 891f–893f
    - vaginoplasty for, 891, 891f–892f, 893–894, 893f
- Distal penile approach, to penile prosthesis implantation, 618
- Distal urethrectomy, in women, 368, 369f
- Diverticulectomy
    - bladder, 171–176, 242–243
    - urethral, female, 322–327
- Diverticulum. *See also specific types*
    - bladder, 171–176, 242–243
    - urachal, 806–807
    - urethral, female, 322–327
- Dondren, urethral injection of, 371
- Donor nephrectomy
    - laparoscopic, 36–43
        - alternatives to, 36
        - contraindications to, 36, 37t
        - donor evaluation for, 36

        - indications for, 36
        - left-sided, 37–41, 38f–41f
        - outcomes and complications of, 42–43, 42t
        - patient positioning for, 37, 38f
        - patient preparation for, 36
        - right-sided, 41
        - surgical techniques in, 36–41, 38f–41f
    - for renal autotransplantation
        - flank, 119–121, 121f
        - midline intraperitoneal approach in, 121–122
- Dorsal flap onlay, for hypospadias, 831–832, 832f
- Double hydrodistention implantation technique, for VUR, 798–799, 798f–799f, 799t
- Double-J stents
    - for megaureter, 758
    - for palliative urinary diversion, 727, 728, 728f
- Dual kidney transplantation, 110, 110f
- Ductus deferens. *See* Vas deferens
- Durasphere, 375–376
- Dynamic sentinel node biopsy, in penile cancer, 585–586, 585f–586f, 591

E

- Eagle–Barrett syndrome. *See* Prune belly (triad) syndrome
- E-aminocaproic acid (Amicar), for hemorrhagic cystitis, 215
- Ebbehoj shunt, 607
- Ectopic adrenal tissue, 2
- Ectopic kidney, 738–748
    - blood supply of, 740–741
    - crossed, 738, 739f–740f
    - diagnosis of, 741
    - embryology of, 738
    - epidemiology of, 738–740
    - location of, 738–740, 741f
    - robotic pyeloplasty for, 744–748, 747f
    - simple, 738
    - surgical management of
        - alternatives to, 742
        - indications for, 741–742
        - outcomes and complications of, 748
        - techniques in, 744–748
    - surgical options for conditions in, 748
- Ectopic scrotum, 905, 905f, 907, 907f
- Eggplant deformity, 630, 630f
- Ejaculation
    - delayed, 503–508
    - disorders of, 503–510
    - retrograde, 508–509
    - retroperitoneal lymph node dissection and, 538, 539f

Ejaculation induction, 503–510
  for delayed ejaculation, 504–508
  for retrograde ejaculation, 508–509
Ejaculatory duct, 445–447
  anatomy of, 446, 456
  assessment of, 445
  histology of, 456
Ejaculatory duct obstruction
  diagnosis of, 456–458, 457f
  medications associated with, 456, 456t
  surgical management of, 456–459
    indications for, 456
    outcomes and complications of, 458–459
    technique in, 458, 458f
Electroejaculation, 506–508, 506f–507f, 507t
Electrosurgery, for benign prostatic obstruction, 253–256
Embolization
  for hemorrhagic cystitis, 216
  for intracaval tumors, 26
  for renal trauma, 97, 97f
En bloc renal transplantation, 109–110, 109f
End cutaneous ureterostomy, for posterior urethral valve, 824, 824f
Endopelvic fascia, 420, 423f
Endopyelotomy, 82
Endoscopic treatment. *See also specific disorders and procedures*
  for benign prostatic obstruction/LUTS, 253–260
  for incontinence in women, 371–379
  for interstitial cystitis/bladder pain syndrome, 222, 227–228, 228t
  for megaureter, 758
  for ureterocele, 802, 803f
  for vesicoureteral reflux, 784, 796–800
Endo Stitch, for pyeloplasty, 84, 86f
Enema, continence
  Malone antegrade, 178, 181, 930–933, 931f–932f
  Monti–Malone, 931–932, 932f
Enhanced Recovery after Surgery (ERAS) protocol, 231, 231t
Enterocele
  McCall culdoplasty for, 429, 430f
  sacrospinous ligament fixation for, 430–431, 431f
  transvaginal repair of, 427–431, 428f–431f
  uterosacral ligament fixation for, 429–430, 430f
Enterocystoplasty, pediatric, 914–915, 916f
Enterovesical fistulas, 202. *See also* Intestinovesical fistulas
Epididymal fluid, 442–443
Epididymal obstruction
  diagnosis of, 481–482
  vasoepididymostomy for, 481–488

Epididymal sperm retrieval, 520–521
  microsurgical, 500, 520–521, 520f
  outcomes of, 520–521
Epididymectomy, 498–503
  anatomic considerations in, 499
  anesthesia for, 499
  closure in, 501
  complete, 500–501
  counseling issues in, 498–499
  handling of vas deferens in, 500
  incision in, 499–500
  indications for, 498, 498t
  for malignancy, 501
  outcomes of, 501–502, 502t
  partial, 500
  postoperative evaluation in, 501
  surgical techniques in, 499–501
Epididymis, 441–443
  anatomy of, 441–443, 442f, 444f, 572–573, 574f
  blood supply of, 443
  development of, 441
  function of, 443
  innervation of, 443
  physical examination of, 441
Epididymoorchitis, simple orchiectomy for, 521
Epispadias
  with bladder exstrophy, 835, 837, 846, 850–851
  surgical repair of, 567, 568f, 850–851, 851f
Erectile disorders. *See also specific types*
  erectile dysfunction, 610–629
  priapism, 569, 603–610
Erectile dysfunction (ED)
  arteriogenic, 620–626
  diagnosis of, 612, 621–622, 621f
  epidemiology of, 620
  etiology of, 620
  medical management of, 622
  penile prosthesis for, 610–619
  priapism and, 603, 609
  vascular surgery for, 620–629
    outcomes and complications of, 624–626, 625f, 625t, 626f, 627–628
    patient selection for, 622
    techniques in, 622–624, 623f–624f, 626–627, 627f–628f
  venogenic (veno-occlusive), 620–622, 626–628
Erection
  artificial, in hypospadias surgery, 828
  physiology of, 620–621

Estrogen, for hemorrhagic cystitis, 216
Ethylene vinyl alcohol copolymer, urethral injection of, 371
Excision and primary anastomosis (EPA), for urethral strictures, 338–339, 341, 343–344, 344f
Exstrophy, bladder, 835–854
  in boys
    complete penile dissection and deep dissection in, 837–840, 840f–841f
    complete primary repair of, 837–842
    lines of dissection in, 837, 837f, 838f
    penile/urethral dissection in, 837, 838f–840f
    primary closure in, 840–842, 841f–842f
  diagnosis of, 835–836, 846
  epispadias with, 835, 837, 846
    surgical repair of, 850–851, 851f
  in girls
    final reconstruction in, 844, 844f
    lines of incision in, 842, 843f
    primary repair technique for, 842–844, 843f–844f
  modern staged repair of, 845–854
  physical manifestations of, 835, 836f
  scrotal anomalies with, 905
  surgical management of, 836–845
    adjunctive hernia repair in, 844
    alternatives to, 847
    bladder, posterior urethral, and abdominal wall closure in, 848–850, 849f
    continence and antireflux procedure in, 852–853, 852f
    goals in, 836
    history of, 846
    indications for, 836, 846–847
    operative considerations in, 837
    osteotomy in, 847–848, 848f
    outcomes and complications of, 845, 853–854
    postoperative care in, 844–845, 845f
    preoperative care in, 836, 847
    techniques in, 836–844, 846–853
    timing and staging of, 847–848
  urinary diversion for, 846, 847
Extra-anatomic pyelovesical prosthetic bypass, 729
Extracorporeal shock wave lithotripsy (ESWL), 130–132, 744
Extraperitoneal bladder repair, 213
Extraperitoneal partial cystectomy, 149–150, 149f–150f
Extraperitoneal repair, of vesicovaginal fistula, 199, 200f
Extravaginal testicular torsion, 547–549, 548f
Extravesical bladder diverticulectomy, 174, 242
Extravesical megaureter surgery, 760–761
Extravesical nephroureterectomy, 187–189, 189f
Extravesical VUR technique, 784–785, 784f–785f

F
Fat, urethral injection of, 371
Fecal incontinence
  Malone antegrade continence enema for, 178, 181, 930–933
  medical management of, 930–931, 930t
Female pseudohermaphrodite, 886. *See also* Disorders of sexual development
Feminizing genitoplasty, 886–894. *See also* Disorders of sexual development
Fengerplasty, 83, 83f
Fibrin glue, for vesicovaginal fistula, 195
Fine needle aspiration (FNA), of small renal mass/cyst, 73–74
Fine needle biopsy, testicular, 517–518, 518f
Fistulas. *See also specific types*
  intestinovesical, 202–209
  ureteral, after renal transplantation, 112–117
  urethral, female, 315–321
  urethral, male, 351, 351f
  vesicovaginal, 193–202
Flap vaginoplasty, 880, 883, 883f, 891, 891f–892f
Flexible robot-assisted ureteroscopy, 307–308, 307f–308f
Foley Y-V technique
  in pyeloplasty, 742, 743f
  in UPJ repair, in horseshoe kidney, 742, 743
Foreskin
  anatomy of, 569
  circumcision of (*See* Circumcision)
  stage T1G1-3 cancer of, 579
Formalin, for hemorrhagic cystitis, 216
46XX disorder of sexual development, 886. *See also* Disorders of sexual development
Fossa navicularis, 313
Fournier gangrene
  circumcision and, 901, 901f
  male genital trauma and, 556, 563–564
Fowler–Stephens procedure
  one-stage, 858–861, 859f–861f
  two-stage, 861, 861f
Fusiform megalourethra, 764, 764f

G
Gastrocystoplasty, augmentation, 178, 916–919, 918f
GAX-collagen, urethral injection of, 373, 374–375
Genesis penile prosthesis, 611, 611f, 611t
Genital trauma, male, 554–566. *See also specific types*
  avulsion, 554–555, 561–562, 561f
  chemical (burns), 563
  classification of, 554
  diagnosis of, 554–557

  - foreign bodies in, 554–555
  - Fournier gangrene in, 556, 563–564
  - penetrating, 554–555, 558–560, 559f–560f
  - radiation-induced, 554, 556, 563, 564f–565f
  - simple orchiectomy for, 522
  - surgical management of, 557–566
    - alternatives to, 557–558
    - indications for, 557
    - outcomes and complications of, 564–566
  - thermal (burns), 554, 555–556, 556f, 562–563, 563f
- Genitoplasty
  - female (*See* Clitoroplasty; *See* Vaginoplasty)
  - feminizing, 886–894
- Germ cell tumors, testicular
  - diagnosis of, 527–528, 532, 532f, 533f
  - organ-preserving surgery for, 532–537
    - alternatives to, 532–533
    - indications for, 532
    - outcomes and complications of, 535–536
    - surgical technique in, 533–534, 533f–536f
  - radical inguinal orchiectomy for, 527–531
  - retroperitoneal lymph node dissection for, 537–547
  - simple orchiectomy for, 521–527
- Gerota fascia, anatomy of, 3–4, 4f
- Glans approximation procedure (GAP), 829, 830f
- Glansectomy, for penile cancer, 580
- Glans penis
  - anatomy of, 567–570, 567f
  - stage T2 cancer of, 580
  - stage T1G1-3 cancer of, 579–580
- Glenn–Anderson repair, of VUR, 788, 788f
- Glutaraldehyde cross-linked bovine collagen (GAX-collagen), urethral injection of, 373, 374–375
- Gomco clamp, for circumcision, 898, 899f
- Gonadotropin-releasing hormone (GnRH), in medical castration, 522
- Goodwin–Hohenfellner technique, for transverse colonic conduit, 663–664, 664f
- Gracilis interposition flap, for rectourethral fistula, 208–209, 208f
- Grayhack shunt, 609

H

- Halban culdoplasty, 432, 432f
- Hammock hypothesis, 379, 388
- Hand-assisted laparoscopic nephroureterectomy, 58, 62–63, 63f
- Heineke–Mikulicz principle, 83
- Hematoma
  - penile, 568–569, 569f
  - scrotal, 557, 557f–558f
- Hematuria–dysuria syndrome, 921

Hemiscrotal agenesis, 905, 907–908
Hemorrhagic cystitis, 214–216
    algorithm for, 216f
    bacterial, 214, 214t
    bladder irrigation for, 214–215
    drug-induced, 214, 214t
    etiology of, 214, 214t
    fungal, 214, 214t
    hypogastric artery embolization for, 216
    intravesical medications for, 215–216
    management of, 214–216, 216f, 216t
    radiation-induced, 214, 214t
    supravesical diversion for, 216
    viral, 214, 214t
Heparin, for interstitial cystitis/bladder pain syndrome, 220
Hermaphrodite, 886. *See also* Disorders of sexual development
Hernia
    inguinal, 864–865
        with bladder exstrophy, 844, 846
        diagnosis of, 865
        outcomes and complications of, 865
        surgical technique for, 865
    umbilical, with bladder exstrophy, 844
High-intensity frequency ultrasound (HIFU), for prostate cancer, 307
HIV infection, circumcision and prevention of, 895
Holmium laser ablation of prostate (HoLAP), 259–260
Holmium laser enucleation of prostate (HoLEP), 256–259, 256t, 257f–258f
Holmium:YAG laser therapy
    for benign prostatic obstruction, 256–260
    for posterior urethral valve, 820
Hormonal therapy, for cryptorchidism, 856
Horseshoe kidney, 738–748
    blood supply of, 738, 739f
    diagnosis of, 741
    embryology of, 738
    epidemiology of, 738
    pyeloplasty for, 742, 743f
    stone surgery in, 744
    surgical management of
        alternatives to, 742
        indications for, 741–742
        outcomes and complications of, 748
        techniques in, 742–744
    tumors in, surgery for, 744, 746f
    ureterocalicostomy for, 744, 745f–746f
“Hostile” bladder, 183
Human chorionic gonadotropin (hCG), for cryptorchidism, 856

Human papilloma virus (HPV), and penile cancer, 576
Hydrocele, 572, 642–647, 864–865
  communicating, 642, 643f
  definition of, 642
  diagnosis of, 642–644, 865
  embryology and etiology of, 642, 643f
  indications for treatment of, 644
  noncommunicating, 643f
  nonsurgical repair of, 644
  surgical repair of, 644–647, 865
    Andrews procedure for, 645–646, 646f
    Jaboulay procedure for, 644–645, 645f, 646f
    Lord procedure for, 646, 647f
    microsurgically assisted hydrocelectomy for, 646–647, 648f
    outcomes and complications of, 647, 865
    patient preparation for, 644
  types of, 643f
  with varicocele, 494
  varicocelectomy and, 495
Hydrocelectomy, microsurgically assisted, 646–647, 648f
Hydrodistention, for VUR, 798–799, 798f–799f, 799t
Hydronephrosis, pyeloplasty for, 753–756
Hydroxyzine, for interstitial cystitis/bladder pain syndrome, 220
Hyperbaric oxygen, for hemorrhagic cystitis, 216
Hypospadias, 826–835
  anterior, treatment of, 828–832
  definition of, 826
  diagnosis of, 826–827
  dorsal flap onlay for, 831–832, 832f
  glans approximation procedure for, 829, 830f
  meatal abnormalities in, 826, 827f
  meatal advancement and glanuloplasty for, 828–829, 830f
  onlay island flap for, 832, 832f
  outpatient repair of, 827–828
  penile curvature in, 826, 827
  posterior, treatment of, 832–834
  skin and scrotal abnormalities in, 826–827
  split prepuce in situ only repair of, 832, 832f
  surgical management of
    age for operation in, 827
    algorithm for, 829f
    artificial erection in, 828
    dressings in, 828
    hemostasis in, 828
    nerve block for, 828
    operative setup for, 828
    outcomes and complications of, 834–835

        postoperative problems in, 834
        preoperative evaluation for, 827
        surgeon's experience in, 827
        techniques in, 826, 827–834
        urethral plate preservation in, 829–830
        urinary diversion in, 828
    Thiersch–Duplay or primary tubularization for, 830, 831f
    tubularized incised plate urethroplasty (Snodgrass modification) for, 830–831, 831f
    two-stage repair of, 833–834, 833f–834f
Hysterectomy
    for rhabdomyosarcoma, 776
    vaginal, with vault suspension, 425–427, 425f–428f

I

Ifosfamide, and hemorrhagic cystitis, 214
Ileal augmentation cystoplasty, 178–184, 913–914, 914f–916f, 920
Ileal conduit urinary diversion, 656–660
    alternatives to, 656
    bowel segment for, 657, 657f
    Bricker technique in, 238, 658–659, 659f
    indications for, 656
    intracorporeal conduit creation in, 656
    in obese patients, 656, 658
    outcomes and complications of, 660
    palliative, 725–726, 725f
    postoperative care in, 659
    preoperative preparation for, 656
    rosebud technique in, 657–658, 658f
    stoma construction in, 657–658, 658f
    surgical technique in, 656–659, 657f–659f
    ureteroenteric anastomoses in, 658–659, 659f
    Wallace technique in, 658–659, 659f
Ileal continent catheterizable reservoir, 697–701
    alternatives to, 698
    indications for, 698
    outcomes and complications of, 701
    patient selection and evaluation for, 698
    postoperative care of, 701
    preoperative preparation for, 698
    surgical technique for, 698–700, 699f–700f
Ileal low-pressure orthotopic bladder substitution, 674–679
    alternatives to, 674
    construction of reservoir in, 676–678, 676f–678f
    cystectomy in, 675
    in obese patients, 678, 678f
    outcomes and complications of, 679
    postoperative care in, 678–679

    preparation of ileum segment for, 675, 675f
    surgical technique for, 675–678, 675f–678f
    ureteroileal end-to-side anastomosis in, 675–676, 676f
    urethral anastomosis in, 676–678, 676f–678f
Ileal orthotopic bladder substitution, 680–688
    approach to female urethra in, 681–684, 681f–684f
    approach to male urethra in, 680–681, 681f
    construction of reservoir for, 684–685, 684f–686f
    cystectomy in, 680–684, 680f
    ileoureteral anastomosis in, 685–687, 687f
    outcomes and complications of, 687–688
    ureteral mobilization in, 680, 680f
Ileal ureteral substitution, 118
Ileocecal pouch (Mainz pouch I), 703–705, 703f–705f, 708f
Ileovesicostomy, Monti–Yang, 706f, 925–927, 926f–928f
Iliococcygeus muscle, 422
Incontinence. *See also* Incontinence, *See also* in children; *See also* Incontinence, *See also* female; *See also* Incontinence, *See also* male
    artificial urinary sphincter for, 393–403
    diagnosis of, 394
    epidemiology of, 393
    etiology of, 393
    sacral neuromodulation for, 411–419
Incontinence, in children
    bladder neck reconstruction for, 810–818
    diagnosis of, 810–811
Incontinence, female
    abdominal retropubic approaches for, 388–392
    artificial urinary sphincter for, 398–400, 400f
    Burch urethropexy for, 388–392
        alternatives to, 389
        indications for, 389
        laparoscopic, 391
        open, 389–391, 390f
        outcomes and complications of, 391–392
    injectable therapies for, 371–379
        agents for, 373–377, 374t
        biomaterials for, 374–375, 374t
        calcium hydroxyapatite for, 376
        Durasphere for, 375–376
        future directions in, 377
        glutaraldehyde cross-linked bovine collagen for, 373, 374–375
        ideal, characteristics of, 371
        injection techniques for, 372–373
        mechanism of action, 371
        outcomes and complications of, 371
        patient selection for, 371–372

    - periurethral, 373
    - Permacol for, 377
    - polyacrylamide hydrogel for, 377
    - postoperative care in, 373
    - silicone polymers for, 375
    - stem cells for, 377
    - synthetic materials for, 375–377
    - transurethral, 372
  - Marshall-Marchetti-Krantz (MMK) procedure for, 388–389
  - radical cystectomy and, 163–164
  - urethral slings for, 379–388
    - alternatives to, 380
    - indications for, 380
    - midurethral, 379–387, 382f–386f
    - outcomes and complications of, 386–387
    - postoperative considerations with, 386
    - preoperative considerations for, 380–381
    - rectus fascia bladder neck, 379–382, 381f–382f, 386–387
    - surgical technique for, 380–386
- Incontinence, male
  - artificial urinary sphincter for, 395–398, 404–405
    - bladder neck cuff placement for, 398
    - inflatable penile prosthesis with, 400
    - perineal cuff placement for, 395–397, 396f
    - after prior failed sling, 402
    - after radiotherapy for prostate cancer, 402–403
    - slings *vs.*, 394, 395t, 404–405
    - transcorporeal cuff placement for, 397, 397f, 398f
    - transverse scrotal incision for placement of, 397–398, 398f–400f
  - inflatable penile prosthesis for, 395t, 400
  - postprostatectomy
    - artificial urinary sphincter for, 404–405, 409
    - diagnosis of, 404
    - male sling for, 403–410
    - prevalence of, 403–404
    - risk factors for, 404
    - surgical indications in, 404
- Indiana pouch, 706–708, 710f
- Inferior vena cava, renal tumor extension to. *See* Intracaval tumors
- Infrapubic approach, to penile prosthesis implantation, 617–618
- Inguinal hernia, 864–865
  - with bladder exstrophy, 844, 846
  - diagnosis of, 865
  - outcomes and complications of, 865
  - surgical technique for, 865
- Inguinal lymph node dissection, in penile cancer, 586–588, 590–596
  - complications of, 595

- flap reconstruction after, 594–595
- indications for, 591
- laparoscopic and robot-assisted, 594
- modified, 594
- perioperative planning and care for, 591–592
- radical, 593–594
- suprainguinal dissection in, 594
- surgical anatomy in, 592–593, 592f–593f
- technique of, 586–588, 587f, 593–595

Inguinal orchiectomy, radical, 527–531
- alternatives to, 528
- complications of, 529–531
- for rhabdomyosarcoma, 775–776
- sperm cryopreservation before, 528
- surgical technique in, 528–529, 528f–531f

Inguinal orchiopexy
- anatomic considerations in, 855f
- technique of, 861–863, 862f–863f

InhibiZone, 611, 613

Injectable therapy
- for bladder neck, 811
- for incontinence in women, 371–379
  - agents for, 373–377, 374t
  - biomaterials for, 374–375, 374t
  - calcium hydroxyapatite for, 376
  - Durasphere for, 375–376
  - future directions in, 377
  - glutaraldehyde cross-linked bovine collagen for, 373, 374–375
  - ideal, characteristics of, 371
  - injection techniques for, 372–373
  - mechanism of action, 371
  - outcomes and complications of, 371
  - patient selection for, 371–372
  - periurethral, 373
  - Permacol for, 377
  - polyacrylamide hydrogel for, 377
  - postoperative care in, 373
  - silicone polymers for, 375
  - stem cells for, 377
  - synthetic materials for, 375–377
  - transurethral, 372
- for interstitial cystitis/bladder pain syndrome, 220–221, 221f
- for vesicoureteral reflux, 784, 796–800, 798f, 799f, 799t

Intergroup Rhabdomyosarcoma Study Group (IRSG), 771, 772, 773t, 777–778

Internal urethrotomy, 338, 340–341, 340f, 342–343

Intersex, 886. *See also* Disorders of sexual development

InterStim. *See* Sacral neuromodulation

Interstitial cystitis/bladder pain syndrome, 217–230
  augmentation cystoplasty for, 219, 222, 223f
  behavioral therapy for, 219–220
  bladder hydrodistention for, 221, 221f–222f, 227–228, 228t
  clinical presentation of, 217
  continent diversion for, 219
  definition of, 218
  denervation for, 227, 228
  diagnosis of, 217–218
  endoscopic resection or fulguration of ulcers in, 222, 227–228, 228t
  indexes of, 218, 219t
  intravesical medication for, 220
  in men, 217
  neuromodulation for, 219
    posterior tibial nerve, 226–227, 227f
    pudendal, 225–226, 225f–226f
    sacral, 224–225
  nonsurgical therapy for, 219–221
  pain management in, 220
  partial cystectomy and substitution cystoplasty for, 222–224, 224f
  pentosan polysulfate sodium for, 220
  sacral nerve stimulation for, 224–225, 228–229, 228t
  surgical management of
    indications for, 218–219, 220f
    outcomes and complications of, 227–229, 228t
    techniques in, 221–227
  total cystectomy with orthotopic neobladder or urinary diversion for, 224
  transvaginal/transrectal myofascial release for, 218–219
  transvaginal trigger point injections for, 220–221, 221f
  in women, 217
Intestinovesical fistulas, 202–209
  colovesical, 202
  definition of, 202
  diagnosis of, 202–203
  enterovesical, 202
  etiology of, 202, 202t
  rectourethral, 202, 204–209
  rectovesical, 202
  surgical management of, 203–209
    one-stage approach in, 203–204, 204f
    outcomes of, 204, 209
    techniques in, 203–209
Intracaval tumors, 26–35
  classification of, 26, 27f
  diagnosis of, 26, 28f
  infrahepatic, 27–31, 29f–30f
  minimal access medial sternotomy for, 33–34, 33f–34f

  - neoadjuvant targeted therapy for, 34–35
  - outcomes and complications of, 35
  - preoperative angioembolization of, 26
  - retrohepatic, 31–33, 31f–32f
  - supradiaphragmatic, 33–34, 33f–34f
  - surgical approach to, 26–34, 29f–34f
  - traditional median sternotomy for, 33
- Intraperitoneal donor nephrectomy, 121–122
- Intraperitoneal partial cystectomy, 150
- Intraperitoneal repair, of vesicovaginal fistula, 197–199, 197f–199f, 200t
- Intraperitoneal simple cystectomy, 146
- Intratubular germ cell neoplasia (ITGCN), testicular biopsy in, 517
- Intravaginal testicular torsion, 547–548, 548f
- Intravesical bladder diverticulectomy, 174, 175f
- Intravesical–extravesical bladder diverticulectomy, 174–175, 176f
- Intravesical–extravesical VUR approach, 789, 790f–791f
- Intravesical medications, for hemorrhagic cystitis, 215–216
- Intravesical megaureter surgery, 758–760, 758f–761f
- Intravesical nephroureterectomy, 187, 187f
- Intravesical VUR technique, 785–789, 786f–789f
- Intrinsic sphincter deficiency (ISD)
  - artificial urinary sphincter for, 393–403
  - postprostatectomy, male sling for, 403–410
  - urethral injection therapy in women for, 371–379
  - urethral slings in women for, 379–388
- Intussusception vasoepididymostomy, 483–485, 484f–485f, 487
- Ischemic priapism, 603–609, 604t

J

- Jaboulay procedure, for hydrocele, 644–645, 645f, 646f
- Joule-Thomson effect, 88

K

- Kaliscinski technique, for megaureter, 760, 761f
- Kidney(s). *See also specific disorders and procedures*
  - anatomy of, 3–6, 3f–6f
  - lymphatic anatomy of, 5
  - nervous innervation of, 5
  - structures contiguous to, 5–6, 6f
  - trauma to, 95–102
  - vascular anatomy of, 4–5, 5f
- Klingsor syndrome, 637
- Kropp urethral lengthening procedure, 814–816, 815f
- KTP laser therapy, for benign prostatic obstruction, 259–260

L

- Labia minora pedicle flap, 318, 319f

Labioplasty, 881, 881f, 890–891, 890f
Laparoendoscopic single-site surgery, 85
Laparoscopic biopsy, renal, 74, 74f
Laparoscopic cyst decortication (LCD), 70–72, 72f
Laparoscopic procedures. *See also specific procedures*
    ablation of small renal masses, 76–81
    adrenalectomy, 87–95
    Burch urethropexy, 391
    calculus disease, 130–132
    cryptorchidism, 856–861
    inguinal lymphadenectomy, 594
    lymphocele repair, 125–130
    nephrectomy, 43–56
        donor, 36–43
        partial, 48–55
        radical, 17, 44–48
    nephrectomy, pediatric, 873–877
    nephropexy, 74–75, 75f
    nephroureterectomy, 56–68, 185
    pyelolithotomy, 83, 85
    pyeloplasty, 81–87, 744–748
    radical cystectomy, 230
    radical cystectomy, robot-assisted, 230–242
    radical prostatectomy, 263–264, 284
    radical prostatectomy, robot-assisted, 263, 284–291, 291
    renal cystectomy, 69–73
    sacral colpopexy, 433, 433f
    seminal vesicle surgery, 454–455, 454f
    transureteroureterostomy, 752
    ureterolysis, 134–136
    varicocele ligation, 132–134
    vesicovaginal fistula repair, 200–201, 200t
    VUR repair, 789–794, 791f–794f
Laser surgery/therapy
    for benign prostatic obstruction, 256–260
    for penile cancer, 579
    for posterior urethral valve, 820
Levator ani, 422
Levator hiatus, 422, 423f
Lichen sclerosis, 577
Lithotripsy, 130–132, 744
Longitudinal intussusception vasoepididymostomy (LIVE), 483–485, 484f–485f, 487
Loop cutaneous ureterostomy, for posterior urethral valve, 823, 823f, 824, 825f
Lord procedure, for hydrocele, 646, 647f
Lower urinary tract symptoms (LUTS), male, 250–269. *See also* Benign prostatic obstruction
Lymphadenectomy
    with nephroureterectomy, 186, 186f

  - with open radical retropubic prostatectomy, 270–271
  - in penile cancer, 578–579, 578f, 585–588
    - complications of, 595
    - general considerations in, 585–586
    - inguinal, 586–588, 587f, 590–596
    - pelvic, 586
  - with prostatectomy, 286
  - with radical cystectomy
    - extended and superextended, 155, 156f, 235, 235f, 236f
    - in men, 152–153, 152f–153f, 155, 156f
    - outcomes of, 239–240
  - in testicular cancer, 537–547
  - in urethral cancer, 370

Lymphoceles
  - diagnosis of, 125–126, 125f–126f
  - laparoscopic repair of, 125–130
    - alternatives to, 127
    - excision of lymphocele in, 128–129, 129f
    - identification of lymphocele in, 128, 129f
    - indications for, 126–127
    - omental wick placement in, 129
    - outcomes and complications of, 130
    - patient positioning for, 127
    - peritoneal access and trocar configuration in, 127–128, 128f
    - postoperative care in, 130
    - preoperative preparation for, 127
    - surgical technique in, 127–130
  - open transperitoneal marsupialization for, 127
  - sclerosing agents for, 127

M

Mackenrodt ligaments, 421, 421f
Macroplastique, 375
MadaJet, 461–462, 461f–462f
Mainz colonic continent catheterizable reservoir
  - colon pouch (Mainz pouch III), 710, 711f, 712f
  - ileocecal pouch (Mainz pouch I), 703–705, 703f–705f, 708f

Mainz enterocystoplasty, 914–915, 916f
Mainz orthotopic bladder substitution, 690, 690f, 695–696
Mainz ureterosigmoidostomy (Mainz pouch II), 718–724, 847
  - colorectal carcinoma with, 722–723
  - construction of, 718–720, 719f–720f
  - continence rates with, 723
  - quality of life with, 723
  - serosa-lined extramural tunnel ureteral implantation of, 720–722, 720f–722f
  - surgical tricks for, 722
  - upper urinary tract safety with, 723

Male pseudohermaphrodite, 886. *See also* Disorders of sexual development
Male sling, 403–410
  adjustable, 408
  artificial urinary sphincter *vs.*, 394, 395t, 404–405, 409–410
  failed, artificial urinary sphincter for, 402, 409
  quadratic, 407–408
    mechanism of action, 408
    outcomes of, 408
    surgical technique for, 407–408, 407f–408f
  rationale for, 405
  removal of, 409, 409f
  retrourethral transobturator, 405–407
    mechanism of action, 406
    outcomes of, 406–407
    surgical technique for, 405–406, 406f
  selecting procedure for, 408–409
Malone antegrade continence enema (MACE), 178, 181, 930–933
  appendicocecostomy in, 931, 931f
  indications for, 930
  outcomes and complications of, 932–933
  surgical techniques in, 931–932, 931f–932f
Marshall-Marchetti-Krantz (MMK) procedure, 388–389, 811
Martius flap
  for bladder neck closure, 331, 332f
  for urethral reconstruction, 320–321, 321f
McCall culdoplasty, 429, 430f
Meatal advancement and glanuloplasty (MAGPI), 828–829, 830f, 850, 851f
Meatal stenosis, penectomy and, 584–585, 585f
Median sternotomy, 33–34, 33f–34f
Median umbilical ligament, 138
Megalourethra, 764, 764f
  surgical repair of, 769, 769f–770f
  urethral reconstruction for, 765
Megameatus with an intact prepuce (MIP), 769, 770f
Megaprepuce. *See* Concealed penis
Megaureter, 757–763
  classification of, 757
  clinical presentation of, 757
  definition of, 757
  diagnosis of, 757
  endoscopic techniques for, 758
  Kaliscinski technique for, 760, 761f
  nonobstructed, nonrefluxing, 757
  obstructed, 757
  pathophysiology of, 757
  refluxing, 757
  refluxing and obstructing, 757

  - Starr plication for, 760, 760f
  - surgical management of, 758–763
    - alternatives to, 758
    - extravesical approach in, 760–761
    - indications for, 758
    - intravesical approach in, 758–760, 758f–761f
    - outcomes and complications of, 763
    - postoperative care in, 762–763
    - robotic reimplant in, 761, 762f
    - staged approach in, 761–762
- Membranous urethra, 312–313
- MESA. *See* Microsurgical epididymal sperm aspiration
- Mesh stents, for palliative urinary diversion, 728–729
- Microdot technique, for vasovasostomy, 477–480, 477f–480f
- Micropenis, 895
- Microscopic-assisted testicular sperm extraction (MicroTESE), 518–519, 519f
- Microsurgical epididymal sperm aspiration (MESA), 500, 520–521, 520f
- Micturition reflex, 143, 143f–144f
- Midodrine, for delayed ejaculation, 505
- Midurethral sling (MUS), 379–387
  - bottom-up retropubic, 384–385
  - inside-out transobturator, 386
  - outcomes and complications of, 386–387
  - outside-in transobturator, 385–386, 385f–386f
  - top-down retropubic, 382–384, 382f–384f
- Millin prostatectomy. *See* Radical prostatectomy, *See* open retropubic
- Mitrofanoff procedure, 702, 923–930
  - alternatives to, 924
  - appendicovesicostomy in, 924–925, 924f–925f
  - continent vesicostomy in, 927–928, 929f
  - flap-valve continence mechanism in, 923, 923f
  - indications for, 923–924
  - Monti–Yang ileovesicostomy in, 925–927, 926f–928f
  - outcomes and complications of, 928–930, 930t
  - preoperative preparation for, 924
  - surgical options for, 923
  - surgical techniques in, 924–928
  - ureterovesicostomy in, 928
- Mixed gonadal dysgenesis, 886. *See also* Disorders of sexual development
- Mogen clamp, for circumcision, 898, 901f
- Mohs micrographic surgery, for penile cancer, 580
- Monopolar transurethral resection of the prostate (M-TURP), 253–255, 255t
- Monti–Malone antegrade continence enema, 931–932, 932f
- Monti–Yang ileovesicostomy, 706f, 925–927, 926f–928f
- Mucus production, augmentation cystoplasty and, 921–922
- Multiple parallel plication (MPP), 654–655
- Myofascial release, transvaginal/transrectal, 218–219

N
Natural orifice transluminal endoscopic surgery (NOTES), 85, 308
Necrotizing fasciitis
    circumcision and, 901, 901f
    male genital trauma and, 556, 563–564
Neobladder. *See* Orthotopic bladder substitution
Neodymium:YAG laser therapy, for penile cancer, 579
Nephrectomy
    donor, for autotransplantation
        flank, 119–121, 121f
        midline intraperitoneal approach in, 121–122
    donor laparoscopic, 36–43
        alternatives to, 36
        contraindications to, 36, 37t
        donor evaluation for, 36
        indications for, 36
        left-sided, 37–41, 38f–41f
        outcomes and complications of, 42–43, 42t
        patient positioning for, 37, 38f
        patient preparation for, 36
        right-sided, 41
        surgical techniques in, 36–41, 38f–41f
    laparoscopic, 43–56
        alternatives to, 44
        indications for, 43–44
        outcomes and complications of, 54–55
        patient preparation and positioning for, 44, 44f
        postoperative care in, 54
        retroperitoneal, 47–48, 48f
        retroperitoneal partial, 53–54
        surgical techniques in, 44–54, 44f–54f
        transperitoneal partial, 48–52, 48f–53f
        transperitoneal radical or total, 44–47, 45f–47f
    partial, 7–15
        complex applications of, 12–13
        complications of, 13–14
        follow-up after, 14
        indications for, 7
        laparoscopic, 48–55
        laparoscopic retroperitoneal, 53–54
        laparoscopic transperitoneal, 48–52, 48f–53f
        pediatric laparoscopic and robot-assisted, 873–877
        polar, in renal trauma, 99–100, 99f
        preoperative planning and patient preparation for, 7–8
        reconstruction in, 12, 12f
        results of, 13

        - robotic, 52–55
        - robotic retroperitoneal, 54, 54f
        - robotic transperitoneal, 52–53, 53f
        - supra-11th rib mini flank surgical incision in, 8–10, 8f–11f
        - surgical techniques in, 8–12, 8f–12f
        - tactics for tumor resection in, 10–12, 10f–11f
    - pediatric laparoscopic, 873–877
        - alternatives to, 873
        - indications for, 873
        - outcomes and complications of, 877
        - retroperitoneal, 875–876, 876f
        - robot-assisted, 873, 876
        - techniques in, 873–876
        - transperitoneal approach in, 873–875, 874f–875f
    - radical, 16–25
        - anterior subcostal incision in, 17f, 22–23
        - flank incision in, 17–19, 17f–20f
        - indications for, 16–17
        - laparoscopic, 17, 44–48, 54–55
        - laparoscopic retroperitoneal, 47–48, 48f
        - laparoscopic transperitoneal, 44–47, 45f–47f
        - outcomes and complications of, 24–25
        - results of, 25
        - rib dissection in, 17–19, 18f–20f
        - surgical techniques in, 17–24, 17f–24f
        - thoracoabdominal incision in, 17f, 20–22, 21f–22f
        - transabdominal chevron incision in, 17f, 22–23, 23f
    - for renal trauma, 98–101
    - upper pole, for ureterocele, 803–804, 804f
- Nephroblastoma. *See* Wilms tumors
- Nephrogenic rests, 731
- Nephropexy, laparoscopic, 74–75, 75f
- Nephroptosis
    - definition of, 74
    - diagnosis of, 75
    - laparoscopic nephropexy for, 74–75, 75f
- Nephrostomy, percutaneous, for palliative urinary diversion, 726–727
- Nephroureterectomy
    - combined open and endoscopic, 191–192, 191f–192f
    - distal ureter management in, 185–193
    - laparoscopic, 56–68, 185–193
        - approach to distal ureter and bladder cuff dissection in, 64–66, 65f
        - complications of, 192
        - conventional, 61–62, 61f
        - extravesical bladder cuff technique in, 188–189, 189f
        - hand-assisted, 58, 62–63, 63f
        - indications for, 58–59, 186

        lymphadenectomy in, 66
        outcomes of, 66–67, 192
        patient positioning for, 60–61, 60f
        patient preparation for, 59–60
        perioperative care and surveillance in, 66
        pluck technique in, 191
        robotic-assisted, 59, 63–64, 64f, 185, 188–189, 188f–189f
        surgical techniques in, 59–66, 188–191, 188f–191f
        transperitoneal radical, 61–66
        transurethral, 190
        transvesical, 188–190, 188f, 190f
        ureteral unroofing technique in, 190–191, 191f
    open, 185–188, 192
        extravesical approach with or without formal bladder cuff in, 187–188
        indications for, 186
        intravesical approach in, 187, 187f
        lymphadenectomy in, 186, 186f
        outcomes and complications of, 192
Nerve-sparing techniques
    in radical cystoprostatectomy, 159
    in retroperitoneal lymph node dissection, 538–539, 539f, 540f
    in robot-assisted laparoscopic radical prostatectomy, 289, 289f
    in robot-assisted radical cystectomy, in men, 233–234
Nesbitt reduction urethroplasty, 769, 769f
Neurogenic bladder, 328–335
    artificial urinary sphincter for, 329
    augmentation cystoplasty for, 177–185
    bladder neck closure for, 329–335, 331f–334f
    etiology of, 328, 329f
    in female patients, 328–334, 331f–333f
    injectable therapy for, 329
    in male patients, 329–330, 334, 334f
    pediatric augmentation cystoplasty for, 910–922
    slings for, 329
Neuromodulation
    posterior tibial nerve, 226–227, 227f, 412
    pudendal, 225–226, 225f–226f
    sacral, 144–145, 224–225, 228–229, 411–419
No-needle local anesthesia, for vasectomy, 461–462, 461f–462f, 465
Nonischemic priapism, 604–605, 604t, 609
Nonobstructive azoospermia, 516
No-scalpel vasectomy, 462, 463f, 465–466, 465f–466f
NOTES. *See* Natural orifice transluminal endoscopic surgery

O

Obstructive azoospermia, 516
Obturator anatomy, 422–423

Occlusive therapy, for vesicovaginal fistula, 194–195
Omphalomesenteric disorders, 807
Onlay dorsal flap (graft)
    for hypospadias, 831–832, 832f
    for substitution urethroplasty, 346, 346f–347f
Onlay island flap, for hypospadias, 832, 832f
Onlay ventral graft, substitution urethroplasty, 344–346, 345f–346f
Onuf nucleus, 143
Open procedures. *See specific types*
Orchalgia, chronic, simple orchiectomy for, 522
Orchiectomy
    partial, 528
    radical inguinal, 527–531
        alternatives to, 528
        complications of, 529–531
        for rhabdomyosarcoma, 775–776
        sperm cryopreservation before, 528
        surgical technique in, 528–529, 528f–531f
    simple, 521–527
        diagnoses requiring, 521–522
        indications for, 522
        medical castration *vs.*, 521, 522
        outcomes and complications of, 526–527
        postoperative care in, 526–527
        preoperative preparation for, 522
        scrotal approach in, 522–524, 523f
        subcapsular, 525, 525f, 526f
        subepididymal, 525–526, 526f
        suprapubic approach in, 524–525, 524f
        surgical technique in, 522–526
        testicular prostheses after, 524–525, 524f, 525f

Orchiopexy (orchidopexy)
    for cryptorchidism
        anatomic considerations in, 854, 855f
        inguinal, 855f, 861–863, 862f–863f
        single-stage laparoscopic, 858–861, 859f–861f
    for prune belly (triad) syndrome, 765, 768–769
    for testicular torsion, 550–553
        indications for, 550
        outcomes and complications of, 552–553
        surgical technique in, 551–552, 551f
Orchitis, simple orchiectomy for, 521–522
Organ-preserving techniques
    in hypospadias surgery, 829–830
    in kidney cancer, 187
    penile, in anterior urethrectomy with perineal urethrostomy, 362–364, 363f–364f
    in radical cystectomy, in men, 159
    in radical cystectomy, in women, 168–169, 169f
    in radical urethrectomy, in women, 368–370, 370f
    in testicular cancer, 532–537
    in ureterocele surgery, 802–803, 802t
Orthotopic bladder substitution, 667–673
    age and, 667
    atraumatic dissection of urethra in, 669
    bowel function and, 668
    bowel segment for, 669–670, 670f
    colonic, 688–697
        alternatives to, 689
        blood supply in, 693, 695f
        construction of reservoir in, 689–693, 690f–694f, 696f
        indications for, 689
        outcomes and complications of, 696–697
        preoperative preparation for, 689
        rationale for, 688
        surgical technique for, 689–695
        ureteral implantation in, 695
    goal of, 667
    ileal, 680–688
        approach to female urethra in, 681–684, 681f–684f
        approach to male urethra in, 680–681, 681f
        construction of reservoir for, 684–685, 684f–686f
        cystectomy in, 680–684, 680f
        ileoureteral anastomosis in, 685–687, 687f
        outcomes and complications of, 687–688
        ureteral mobilization in, 680, 680f
    ileal low-pressure, 674–679
        alternatives to, 674
        construction of reservoir in, 676–678, 676f–678f

        - cystectomy in, 675
        - in obese patients, 678, 678f
        - outcomes and complications of, 679
        - postoperative care in, 678–679
        - preparation of ileum segment for, 675, 675f
        - surgical technique for, 675–678, 675f–678f
        - ureteroileal end-to-side anastomosis in, 675–676, 676f
        - urethral anastomosis in, 676–678, 676f–678f
    - indications for, 674
    - in interstitial cystitis/bladder pain syndrome, 224
    - liver function and, 668
    - long-term follow-up in, 672, 673f
    - metabolic acidosis with, 672
    - outcomes of, 667
    - paracollicular/bladder neck biopsy and, 668
    - patient motivation/mental status and, 667
    - patient selection for, 667, 667t, 674, 689
    - postoperative management of, 671–672, 671t
    - preoperative preparation for, 668
    - preservation of pelvic innervation in, 668, 669f
    - in radical cystectomy, 158, 159f, 236–237, 237f–239f, 240
    - renal function and, 667–668
    - surgical technique for, 668–670
    - ureter management in, 669
    - urinary continence status and, 668
    - voiding and urinary continence with, 671–672
- Orthotopic kidney transplantation, 109, 109f
- Orthotopic neobladder. *See* Orthotopic bladder substitution
- Outside-in transobturator midurethral sling, 385–386, 385f–386f
- Overactive bladder
    - alternative therapies for, 178, 412
    - augmentation cystoplasty for, 177–185
    - definition of, 411
    - diagnosis of, 411–412
    - interstitial cystitis/bladder pain syndrome *vs.*, 218
    - male, benign prostatic obstruction and, 250
    - sacral neuromodulation for, 411–419
    - surgical indications in, 412
- Oxazaphosphorines, and hemorrhagic cystitis, 214

P

- Painful bladder syndrome. *See* Interstitial cystitis/*See* bladder pain syndrome
- Palliative urinary diversion, 724–730
    - bilateral ureterostomy with single stoma for, 726
    - double-J stents for, 727, 728, 728f
    - eliminating function of contralateral kidney in, 727
    - extra-anatomic pyelovesical prosthetic bypass for, 729

  - ileal conduit for, 725–726, 725f
  - indications for, 724–725
  - metallic mesh stents for, 728–729
  - percutaneous nephrostomy for, 726–727
  - sigmoid colon conduit for, 726
  - surgical technique for, 725–727
  - transureteral cutaneous ureterostomy for, 726
  - transureteropyelocutaneous ureterostomy for, 726
  - transverse colon conduit for, 726
  - transverse retubularized colon segment for, 729, 729f
  - for ureteral obstruction, 727–729, 728f–729f
  - ureterocutaneostomic stoma for, 726
- Paquin repair, of VUR, 789, 790f–791f
- Paraffin wax, urethral injection of, 371
- Paraphimosis, 896, 896f
- Paratesticular rhabdomyosarcoma, 773, 774f, 775–776, 777f, 779–780
- Paravaginal vaginal repair, 434
- Paravesical approach, to seminal vesicle, 452–453
- Partial cystectomy, 148–150
  - alternatives to, 149
  - extraperitoneal, 149–150, 149f–150f
  - indications for, 148–149
  - for interstitial cystitis/bladder pain syndrome, 222–224, 224f
  - intraperitoneal, 150
  - outcomes and complications of, 150
  - for rhabdomyosarcoma, 775
  - surgical technique in, 149–150, 149f–150f
  - urachal excision with, 242
- Partial epididymectomy, 500
- Partial nephrectomy (PN), 7–15
  - complex applications of, 12–13
  - complications of, 13–14
  - follow-up after, 14
  - indications for, 7
  - laparoscopic, 48–55
    - outcomes and complications of, 54–55
    - retroperitoneal, 53–54
    - transperitoneal, 48–52, 48f–53f
  - pediatric laparoscopic and robot-assisted, 873–877
  - polar, in renal trauma, 99–100, 99f
  - preoperative planning and patient preparation for, 7–8
  - reconstruction in, 12, 12f
  - results of, 13
  - robotic, 52–55
    - outcomes and complications of, 54–55
    - retroperitoneal, 54, 54f
    - transperitoneal, 52–53, 53f

    supra-11th rib mini flank surgical incision in, 8–10, 8f–11f
    surgical techniques in, 8–12, 8f–12f
    tactics for tumor resection in, 10–12, 10f–11f
Partial orchiectomy, 528
Partial penectomy
    complications of, 584–585, 585f
    indications for, 580
    postoperative care in, 584–585
    surgical technique in, 581, 581f–582f
Partial ureterostomy, for ureterocele, 803–804, 804f
Partial urethrectomy, for urethral cancer in men, 364–365
Partial urogenital mobilization (PUM), 882f, 883–884
Patent urachus, 806–807, 807f. *See also* Urachal anomalies
Pediatric patients. *See also specific disorders and procedures*
    artificial urinary sphincter in, 400–401
    augmentation cystoplasty in, 400–401, 910–922
    laparoscopic nephrectomy in, 873–877
    laparoscopic pyeloplasty in, 866–872
    open pyeloplasty, 753–756
    partial nephrectomy in, laparoscopic and robot-assisted, 873–877
Pelvic bones, 420
Pelvic diaphragm, 420–422
Pelvic fascia
    anatomy of, 246–247, 247f, 420–422
    nomenclature for, 246
Pelvic floor
    anatomy of, 420–423, 420f–423f
    muscles of, 422
Pelvic floor muscle rehabilitation, 389
Pelvic fracture
    bladder entrapment in, 212, 213f
    bladder trauma in, 210–212
    erectile dysfunction with, 620
Pelvic fracture urethral injuries (PFUIs), 356–359
    alternative therapy for, 358
    delayed urethroplasty for, 359
    diagnosis of, 356–357, 357f
    open suprapubic catheter placement for, 358–359, 359f
    outcomes and complications of, 359
    surgical indications in, 357–358
    surgical technique for, 358–359, 359f
Pelvic lymph node dissection (PLND)
    in orthotopic bladder substitution, 675, 680, 680f
    in penile cancer, 586
    in robot-assisted laparoscopic radical prostatectomy, 286
Pelvic organ prolapse (POP), 420–440
    anatomy of pelvic support and, 420–423, 420f–423f

    anterior colporrhaphy for, 434, 435f
    conservative management of, 424
    diagnosis of, 423–424, 424f
    etiology of, 420
    McCall culdoplasty for, 429, 430f
    pathophysiology of, 423
    perineal body reconstruction for, 437, 437f–438f
    posterior colporrhaphy for, 434–436, 436f–437f
    risk factors for, 423
    sacral colpopexy for
        laparoscopic, 433, 433f
        open, 431–433, 432f–433f
        robot-assisted laparoscopic, 433
    sacrospinous ligament fixation for, 430–431, 431f
    site-specific rectocele repair for, 436–437
    surgical management of, 424–439
        alternatives to, 424
        anterior compartment, 433–434, 439
        apical compartment, 425–433, 438–439
        basic tenets of, 424
        complications of, 437–438
        indications for, 424
        outcomes of, 438–439
        posterior compartment for, 434–437, 439
        postoperative care in, 437
        techniques in, 424–437
    transvaginal enterocele repair for, 427–431, 428f–431f
    uterosacral ligament fixation for, 429–430, 430f
    vaginal hysterectomy with vault suspension for, 425–427, 425f–428f
    vaginal paravaginal repair for, 434
Pelvioureterostomy-en-Y, for posterior urethral valve, 823–824, 823f
Peña posterior sagittal anorectovaginourethroplasty (PSARVUP), 882
Penectomy
    partial
        indications for, 580
        surgical technique in, 581, 581f–582f
    total
        indications for, 580
        technique of, 583–584, 583f–584f
Penile amputation, 636–641
    outcomes of, 641
    postoperative care in, 641
    preservation of severed penis in, 637
    reconstruction of nonsalvageable penis (stump) in, 637–641, 639f–6401f
    replantation of viable penis in, 637, 638f–639f
    self-mutilation and, 637
    surgical complications in, 641

Penile cancer, 576–589
  circumcision for, 578
  circumcision for prevention of, 576
  cryotherapy for, 579
  diagnosis of, 577–579, 577f–579f, 590–591
  epidemiology of, 576, 590
  glansectomy for, 580
  histologic subtypes of, 576
  HPV and, 576
  laser therapy for, 579
  lymph node management in, 578–579, 578f, 585–588
    complications of, 595
    dynamic sentinel node biopsy in, 585–586, 585f–586f, 591
    general considerations in, 585–586
    inguinal dissection technique in, 586–588, 587f, 590–596
    pelvic dissection technique in, 586
    workflow diagram for, 592f
  Mohs micrographic surgery for, 580
  natural history of, 576
  partial penectomy for, 580, 581, 581f–582f
  radiation therapy for, 580–581
  risk factors for, 576
  stage T3-4, 580–581
  stage Ta-Tis, 579
  stage T1G1-3, of foreskin, 579
  stage T1G1-3 of glans, 579–580
  stage T2 of corpora, 580
  stage T2 of glans, 580
  staging of, 577, 578t, 590–591, 590t
  surgical management of, 576–577, 579–585
    complications of, 584–585, 585f
    degree of resection and margins in, 578–579
    follow-up in, 588
    indications for, 579–581
    postoperative care in, 584–585
    technique in, 581–584
  total penectomy for, 583–584, 583f–584f
  wide local excision for, 580
Penile curvature
  acquired, 650
  congenital, 650–655
    classification of, 650, 650f
    diagnosis of, 651, 651f
    incision and plication for, 651–654, 652f–654f
    multiple parallel plication for, 654–655
    outcomes and complications of, 655
    penile disassembly for, 655

        surgical indications in, 651
        surgical technique for, 651–655
        Yachia longitudinal plication for, 654, 654f
    hypospadias and, 826, 827, 833–834, 834f
Penile disassembly, for congenital curvature, 655
Penile hematoma, 568–569, 569f
Penile hyposensitivity, age-related, 504
Penile preservation, in anterior urethrectomy with perineal urethrostomy, 362–364, 363f–364f
Penile prosthesis, 610–619
    alternatives to, 613
    currently available, 611, 611f–612f, 611t
    for erectile dysfunction, 610–619
    for incontinence, 395t, 400
    indications for, 612–613
    infection/infection prevention with, 611, 613, 618–619
    mechanical, 611, 611f
    multiple-component, 611–612, 612f
    outcomes and complications of, 618–619
    for Peyronie disease, 602, 612–613
    for priapism, 609–610
    reliability of, 610, 619
    semirigid, 611, 611f, 619
    surgical implantation of, 613–618
        distal penile (subcoronal) approach in, 618
        infrapubic approach in, 617–618
        “no touch” technique in, 613
        penoscrotal approach in, 613–617, 613f–617f
Penile reconstruction
    anatomy and, 570, 571f
    postoperative care in, 641
    stump, from amputation, 637–641, 639f–640f
Penile replantation, 636–641
    nonsalvageable penis (stump) for, 637–641, 639f–640f
    outcomes and complications of, 641
    postoperative care in, 641
    preservation of severed penis for, 637
    surgical technique for, 637–641
    viable penis for, 637, 638f–639f
Penile rupture (fracture), 629–632
    conservative management of, 630
    diagnosis of, 630, 630f
    etiology of, 629–630
    surgical management of, 630–632
        alternatives to, 630
        indications for, 630
        outcomes and complications of, 632
        technique in, 630–632, 631f

Penile skin loss, 632–634
  diagnosis of, 632, 632f
  surgical management of
    indications for, 632
    outcomes and complications of, 634
    technique in, 632–634, 633f–634f
    vacuum-assisted closure in, 633–634, 634f
Penile trauma, 629–636. *See also specific types*
  blunt, 629–632
  penetrating, 634–636
    alternative therapy for, 635
    diagnosis of, 634
    outcomes and complications of, 636
    surgical indications in, 634–635
    surgical technique for, 635, 635f
Penile urethral trauma, 353–356
Penile vascular surgery, 620–629
  alternative treatments to, 622
  for arteriogenic erectile dysfunction, 622–626
    outcomes and complications of, 624–626, 625f, 625t, 626f
    patient selection for, 622
    techniques in, 622–624, 623f–624f
  for venogenic (veno-occlusive) erectile dysfunction, 626–628
    outcomes and complications of, 627–628
    patient selection for, 626
    technique in, 626–627, 627f–628f
Penile vibratory stimulation, 505–506, 505f
Penis. *See also specific disorders and procedures*
  anatomy of, 554, 554f, 567–572
  anomalies as contraindication to circumcision, 895, 895f
  blood supply of, 570, 570f–572f
  concealed, 895, 901–904
  erectile tissue of, 569
  innervation of, 571–572, 572f–573f
  lymphatics of, 570–571
  structure of, 567–570, 567f–570f
Penoscrotal approach, to penile prosthesis implantation, 613–617, 613f–617f
Penoscrotal transposition, 905, 906, 906f
Periaqueductal gray (PAG), 143, 143f
Perineal body
  anatomy of, 421–422
  reconstruction of, 437, 437f–438f
  repair of, 422f
Perineal cuff placement, for artificial urinary sphincter, 395–397, 396f
Perineal prostatectomy, radical, 276–284
  alternatives to, 277
  bladder neck reconstruction in, 282–283, 282f

- closure in, 283, 283f
- history of, 276
- incision and dissection in, 278–282, 279f–281f
- indications for, 277
- instrumentation for, 278, 278f
- outcomes and complications of, 283–284
- patient positioning for, 277–278, 277f
- pelvic visualization in, 278, 278f
- postoperative care in, 283, 283t
- surgical technique in, 277–283

Perineal urethrostomy
- anterior urethrectomy with, 362–364, 363f–364f
- total penectomy with, 583–584, 584f

Peripheral nerve evaluation (PNE), for sacral neuromodulation, 412–413

Peritoneal folds, 138–139, 138f

Periurethral glands, 448

Periurethral injection, for incontinence in women, 373

Perlman syndrome, 731

Permacol, 377

Pessary, 389, 424

Peyronie disease, 567, 568f, 596–603
- clinical presentation of, 596, 596f
- corporoplasty or corporoplication procedures for, 598
- dermal graft for, 601–602, 601f–602f
- diagnosis of, 596–597, 597f
- etiology of, 596
- excisional technique for, 598
- incisional technique for, 598
- nonincisional or 16-dot technique for, 598
- penile prosthesis in, 602, 612–613
- plaque incision/excision for, 598–601, 599f–600f
- small intestine submucosa graft for, 602–603, 602f
- surgical management of, 597–603
  - indications for, 597–598
  - skin incision for, 598
  - technique in, 598–603

Phenol, for hemorrhagic cystitis, 216

Phimosis, circumcision in, 896

Photoselective vaporization of the prostate (PVP), 259–260

Pippi Salle urethral lengthening procedure, 816–817, 816f

Plastibell, 898, 900f, 901f

Pluck technique, in nephroureterectomy, 191

Polar partial nephrectomy, 99–100, 99f

Politano–Leadbetter repair, of VUR, 786–788, 787f

Polyacrylamide hydrogel, urethral injection of, 377

Pontine micturition center (PMC), 143, 143f–144f

Posterior tibial nerve stimulation, 226–227, 227f, 412

Posterior urethral valve (PUV), 818–825
  cutaneous pyelostomy for, 822–823, 822f–823f, 824
  diagnosis of, 818–819, 819f
  end cutaneous ureterostomy for, 824, 824f
  high loop cutaneous ureterostomy for, 823, 823f, 824, 825f
  pelvioureterostomy-en-Y for, 823–824, 823f
  percutaneous nephrostomy tube for, 824
  supravesical diversion for, 822–824, 822f–825f
  surgical management of, 819–825
    alternatives to, 819
    indications for, 819, 819f
    outcomes and complications of, 824–825
    techniques of, 819–824
  transurethral ablation of, 819–820, 820f
  vesicostomy for, 820–822, 821f
Potassium sensitivity test (PST), 218
Potassium titanyl phosphate laser ablation of prostate, 259–260
Pregnancy, augmentation cystoplasty in, 184
Prepuce, male
  anatomy of, 569
  circumcision of (*See* Circumcision)
  stage T1G1-3 cancer of, 579
Preputioplasty, 896–897
Priapism, 569, 603–610
  Al-Ghorab shunt for, 607–608, 608f
  algorithm for management of, 606f
  clinical characteristics for, 605
  complications of, 609–610
  corporal cannulation for, 608
  corporo-deep dorsal vein shunt for, 609
  corporoglandular shunts for, 607–608, 608f
  corporo-saphenous vein shunt for, 609
  corporospongiosal shunts for, 608–609
  definition of, 603
  diagnosis of, 606
  Ebbehoj shunt for, 607
  epidemiology of, 605
  etiology of, 604–605, 604t
  ischemic, 603–609, 604t
  medical therapy for, 606–607
  nonischemic, 604–605, 604t, 609
  pathophysiology of, 605–606
  penile prosthesis for, 609–610
  proximal shunts for, 608–610
  risk factors for, 605
  surgical management of, 607–610
  Winter shunt for, 607, 608f

Prostaglandins, for hemorrhagic cystitis, 215
Prostate, 245–250. *See also specific disorders and procedures*
    embryology of, 245
    enlargement of (*See* Benign prostatic obstruction)
    gross anatomy of, 245
    lymphatic anatomy of, 248
    neurologic anatomy of, 247–248, 248f–249f
    relationship with seminal vesicles, 245, 245f
    vascular anatomy of, 247–248, 248f
    zonal anatomy of, 246, 246f
Prostate cancer
    artificial urinary sphincter after radiotherapy for, 402–403
    cryotherapy for, 306
    diagnosis of, 276–277, 292
    flexible robot-assisted ureteroscopy for, 307–308, 307f–308f
    focal therapy for, 306–307
    high-intensity frequency ultrasound for, 307
    localized, brachytherapy for, 291–300
    magnetic resonance imaging of, 300–306, 302f–306f
    miniature robots for, 308, 309f
    natural orifice transluminal endoscopic surgery for, 308
    open radical retropubic prostatectomy for, 269–276
    radical perineal prostatectomy for, 276–284
    robot-assisted laparoscopic radical prostatectomy for, 284–291
    simple orchiectomy for, 521–522
    urothelial cell, 361t, 362
Prostatectomy
    complications of, 267
    incontinence after
        artificial urinary sphincter for, 404–405, 409
        diagnosis of, 404
        male sling for, 403–410
        prevalence of, 403–404
        risk factors for, 404
        surgical indications in, 404
    laparoscopic, 263–264, 284
    open, 260–263
    open radical retropubic, 261–262, 262f–263f, 269–276
        complications of, 275–276
        control of prostatic vascular pedicles in, 274, 274f
        dissection of seminal vesicles in, 274
        dividing urethra in, 272–273, 272f–273f
        identification and preparation of prostate in, 271
        incision in, 270
        incision of endopelvic fascia in, 271, 271f
        indications for, 269–270
        ligation of dorsal vein complex in, 271–272, 271f–272f

    - neurovascular bundle preservation in, 273
    - opening of Denonvilliers fascia in, 274
    - operative technique in, 270–275
    - patient positioning for, 270, 270f
    - pelvic lymphadenectomy in, 270–271
    - posterior mobilization in, 273, 273f
    - postoperative care in, 275
    - preoperative preparation for, 270
    - reconstruction of bladder neck in, 274–275, 275f
    - transection of bladder neck in, 274, 274f
    - vesicourethral anastomosis in, 275, 275f
    - wound closure in, 275
- pelvic fascia and, 246–247, 247f
- radical, with en bloc urethrectomy, 365–366, 366f–367f
- radical perineal, 276–284
    - alternatives to, 277
    - bladder neck reconstruction in, 282–283, 282f
    - closure in, 283, 283f
    - history of, 276
    - incision and dissection in, 278–282, 279f–281f
    - indications for, 277
    - instrumentation for, 278, 278f
    - outcomes and complications of, 283–284
    - patient positioning for, 277–278, 277f
    - pelvic visualization in, 278, 278f
    - postoperative care in, 283, 283t
    - surgical technique in, 277–283
- robot-assisted laparoscopic radical, 263, 284–291
    - anesthetic considerations in, 285
    - anterior approach in, 285, 288, 288f
    - benefits of, 284
    - bladder neck dissection in, 287–288, 287f–288f
    - complications of, 290–291
    - dissection of vasa and seminal vesicles in, 285–286, 288, 288f
    - division of dorsal vein complex and urethra in, 289, 289f–290f
    - exposure of prostatic apex in, 286–287, 287f
    - indications for, 284–285
    - ligation of dorsal vein complex in, 287, 287f
    - mobilization of bladder in, 286, 286f
    - nerve-sparing technique in, 289, 289f
    - patient positioning for, 285
    - pelvic lymph node dissection in, 286
    - portal placement and docking in, 285
    - posterior approach in, 285–286
    - posterior dissection between prostate and rectum in, 289
    - postoperative care in, 290
    - preoperative preparation for, 285

        - specimen retrieval and port closure in, 290
        - as standard of care, 284
        - surgical team for, 285
        - surgical technique in, 285–290
        - vascular control of lateral pedicles in, 289, 289f
        - vesicourethral anastomosis in, 290, 290f
    - robot-assisted laparoscopic simple, 263–264
    - suprapubic, 260–261, 261f–262f
- Prostate-sparing radical cystectomy, 159
- Prostatic rhabdomyosarcoma, 772–773, 775, 776f, 779, 780f
- Prostatic urethra, anatomy of, 246, 312–313
- Prostatic urethral lift (PUL), 264–265, 264f–265f
- Proximal shunts, for priapism, 608–610
- Prune belly (triad) syndrome, 763–770
    - abdominal wall reconstruction in, 765, 767–768, 768f
    - anomalies associated with, 763–764
    - classification of, 764
    - diagnosis of, 764
    - distal cutaneous ureterostomy in, 766
    - epidemiology of, 763
    - megalourethra in, 764f
    - orchiopexy in, 765, 768–769
    - reduction cystoplasty in, 765, 767, 767f
    - surgical management of, 765–770
        - alternatives to, 765
        - indications for, 765
        - outcome and complications of, 769–770
        - techniques in, 766–769
    - ureteral reconstruction in, 765, 766–767, 766f
    - urethral reconstruction in, 765, 769, 769f–770f
    - urinary tract reconstruction in, 765
    - vesicostomy for, 766
- Pseudoephedrine, for delayed ejaculation, 505
- Pseudohermaphrodite, 886. *See also* Disorders of sexual development
- Pubocervical fascia, 422
- Pubococcygeus muscle, 422
- Puboprostatic ligaments (PPLs), 246–247
- Puborectalis muscle, 422
- Pubourethral ligaments, 420, 420f
- Pubovaginal sling, 320f, 321, 812–813, 812f
- Pudendal neuromodulation, 225–226, 225f–226f
- Pull-through vaginoplasty, 881, 882
- Pyelolithotomy, laparoscopic, 83, 85
- Pyeloplasty
    - laparoscopic, 81–87
        - alternatives to, 82
        - Anderson-Hynes dismembered method of, 83–85, 83f, 85f, 86f

        - contraindications to, 81–82
        - cystoscopy and retrograde ureterography for, 82
        - drain placement and exit in, 85
        - Endo Stitch for, 85, 86f
        - entry and port placement in, 82, 83f
        - exposure of operative field in, 82
        - Fengerplasty method of, 83, 83f
        - indications for, 81
        - instrumentation for, 82
        - intraoperative complications of, 86–87
        - literature review of, 87
        - mini-method of, 85
        - natural orifice method of, 85
        - patient positioning for, 82
        - postoperative care in, 86
        - postoperative complications in, 87
        - preoperative preparation for, 82
        - pyelolithotomy in, 83, 85
        - robotic-assisted, 85–86, 86f
        - selecting type of repair in, 83, 83f–84f
        - single-site method of, 85
        - surgical alternatives in, 85–86
        - surgical technique in, 82–85
        - UPJ dissection in, 82–83
        - ureteral stent placement for, 82
        - Y-V plasty method of, 83, 84f, 85
    - pediatric laparoscopic, 866–872
        - alternatives to, 867
        - complications of, 871–872
        - indications for, 867
        - outcomes of, 871–872, 871t
        - patient positioning for, 867, 867f
        - retroperitoneoscopic approach in, 868–869, 868f–869f
        - robot-assisted, 744–748, 747f, 866, 870–871, 870f–871f
        - special considerations in, 870
        - techniques in, 867–871
        - transperitoneal approach in, 867f, 869, 869f–870f
    - pediatric open, 753–756
        - alternatives to, 754
        - for ectopic kidney, 744–748, 747f
        - for horseshoe kidney, 742, 743f
        - indications for, 753
        - outcomes and complications of, 748, 756
        - surgical technique for, 754–756, 754f–756f
- Pyelostomy, cutaneous, for posterior urethral valve, 822–823, 822f–823f, 824
- Pyelotransverse pyelocutaneostomy, 664–665, 665f
- Pyelovesical prosthetic bypass, extra-anatomic, 729

Pyelovesicostomy, in ectopic kidney, 748

Q

- Quackle shunt, 608–609
- Quadratic sling, 407–408
    - mechanism of action, 408
    - outcomes of, 408
    - surgical technique for, 407–408, 407f–408f

R

- Radiation therapy
    - hemorrhagic cystitis induced by, 214
    - internal (*See* Brachytherapy)
    - for penile cancer, 580–581
    - for rhabdomyosarcoma, 774–775
    - scrotal trauma in, 554, 556, 563, 564f–565f
    - for urethral carcinoma, 362
- Radical cystectomy
    - lymphadenectomy with
        - extended and superextended, 155, 156f, 235, 235f, 236f
        - in men, 152–153, 152f–153f, 155, 156f
        - outcomes of, 239–240
    - in men, 151–161
        - alternatives to, 151
        - anesthesia and instrumentation for, 152
        - cystoprostatectomy in, 153–159, 153f–159f
        - indications for, 151
        - initial exposure in, 152
        - outcomes and complications of, 160
        - patient positioning for, 152
        - patient preparation for, 151–152
        - postoperative care in, 159–160
        - prostate-sparing, 159
        - radical cystoprostatectomy with nerve sparing in, 159
        - radical cystoprostatectomy with orthotopic bladder substitution in, 158, 159f
        - robotic, 233–234
        - surgical technique in, 151–160
        - urethral cancer recurrence after, 364
    - in orthotopic bladder substitution, 675, 680–684, 680f
    - orthotopic neobladder in, 158, 159f, 236–237, 237f–239f
    - for rhabdomyosarcoma, 775
    - robot-assisted, 230–242, 230–244
        - alternatives to, 230–231
        - anatomic orientation in, 231
        - anterior dissection in, 233
        - complications of, 240–241
        - costs of, 241

        - Enhanced Recovery after Surgery protocol in, 231, 231t
        - functional outcomes of, 240
        - indications for, 230
        - lateral dissection of bladder and control of vascular pedicles in, 232–233, 233f
        - learning curve in, 241
        - lymphadenectomy in, 235, 235f, 236f, 239–240
        - in men, nerve-sparing modifications in, 233–234
        - mobilization and division of ureters in, 231
        - oncologic outcomes of, 238–240
        - patient positioning and port placement in, 231, 232f
        - postoperative care in, 238
        - preoperative preparation for, 231
        - quality of life after, 241
        - retrovesical dissection in, 231–232, 232f
        - specimen entrapment in, 233
        - surgical margins in, 239
        - transection of dorsal vein complex and membranous urethra in, 233
        - urinary diversion in, 236–238, 236f–238f, 240
        - in women, 169–170, 234–235, 234f
    - in women, 161–171
        - age and medical comorbidities in, 163
        - alternatives to, 162
        - anatomic considerations in, 163–164
        - challenges and concerns in, 161
        - “early,” 161
        - extent of, paradigm for, 162, 163t
        - female continence and, 163–164
        - female sexual function and, 164
        - indications for, 161–162
        - intractable local symptoms and, 162
        - in muscle-invasive disease, 161–162
        - in non–muscle-invasive disease, 162
        - outcomes and complications of, 163, 170
        - pelvic exenteration in, 161, 164–166, 164f–166f, 234, 234f
        - postoperative care in, 170
        - preoperative care in, 162–163
        - preoperative considerations in, 162
        - quality of life measures in, 163
        - reproductive organ preservation in, 168–169, 169f, 235
        - retrograde dissection and urethral-sparing technique in, 169, 169f
        - robotic, 169–170, 234–235
        - surgical technique in, 163–170
        - urethrectomy in, 167, 167f
        - vaginal reconstruction in, 168, 168f
- Radical inguinal lymphadenectomy, 593–594
- Radical inguinal orchiectomy, 527–531
    - alternatives to, 528

  - complications of, 529–531
  - for rhabdomyosarcoma, 775–776
  - sperm cryopreservation before, 528
  - surgical technique in, 528–529, 528f–531f
- Radical nephrectomy, 16–25
  - anterior subcostal incision in, 17f, 22–23
  - flank incision in, 17–19, 17f–20f
  - indications for, 16–17
  - laparoscopic, 17, 44–48
    - outcomes and complications of, 54–55
    - retroperitoneal, 47–48, 48f
    - transperitoneal, 44–47, 45f–47f
  - outcomes and complications of, 24–25
  - results of, 25
  - rib dissection in, 17–19, 18f–20f
  - surgical techniques in, 17–24, 17f–24f
  - thoracoabdominal incision in, 17f, 20–22, 21f–22f
  - transabdominal chevron incision in, 17f, 22–23, 23f
- Radical prostatectomy
  - en bloc urethrectomy with, 365–366, 366f–367f
  - open retropubic, 261–262, 262f–263f, 269–276
    - complications of, 275–276
    - control of prostatic vascular pedicles in, 274, 274f
    - dissection of seminal vesicles in, 274
    - dividing urethra in, 272–273, 272f–273f
    - identification and preparation of prostate in, 271
    - incision in, 270
    - incision of endopelvic fascia in, 271, 271f
    - indications for, 269–270
    - ligation of dorsal vein complex in, 271–272, 271f–272f
    - neurovascular bundle preservation in, 273
    - opening of Denonvilliers fascia in, 274
    - operative technique in, 270–275
    - patient positioning for, 270, 270f
    - pelvic lymphadenectomy in, 270–271
    - posterior mobilization in, 273, 273f
    - postoperative care in, 275
    - preoperative preparation for, 270
    - reconstruction of bladder neck in, 274–275, 275f
    - transection of bladder neck in, 274, 274f
    - vesicourethral anastomosis in, 275, 275f
    - wound closure in, 275
  - perineal, 276–284
    - alternatives to, 277
    - bladder neck reconstruction in, 282–283, 282f
    - closure in, 283, 283f
    - history of, 276

        incision and dissection in, 278–282, 279f–281f
        indications for, 277
        instrumentation for, 278, 278f
        outcomes and complications of, 283–284
        patient positioning for, 277–278, 277f
        pelvic visualization in, 278, 278f
        postoperative care in, 283, 283t
        surgical technique in, 277–283
    robot-assisted laparoscopic, 263, 284–291
        anesthetic considerations in, 285
        anterior approach in, 285, 288, 288f
        benefits of, 284
        bladder neck dissection in, 287–288, 287f–288f
        complications of, 290–291
        dissection of vasa and seminal vesicles in, 285–286, 288, 288f
        division of dorsal vein complex and urethra in, 289, 289f–290f
        exposure of prostatic apex in, 286–287, 287f
        indications for, 284–285
        ligation of dorsal vein complex in, 287, 287f
        mobilization of bladder in, 286, 286f
        nerve-sparing technique in, 289, 289f
        patient positioning for, 285
        pelvic lymph node dissection in, 286
        portal placement and docking in, 285
        posterior approach in, 285–286
        posterior dissection between prostate and rectum in, 289
        postoperative care in, 290
        preoperative preparation for, 285
        specimen retrieval and port closure in, 290
        as standard of care, 284
        surgical team for, 285
        surgical technique in, 285–290
        vascular control of lateral pedicles in, 289, 289f
        vesicourethral anastomosis in, 290, 290f
Radiofrequency ablation
    of adrenal lesions, 88–89
    laparoscopic, of small renal masses, 76–81
        complications of, 79–80, 80t
        length of cycle in, 78, 79t
        outcomes of, 80
        postoperative care in, 79
        surgical technique in, 78, 78f
    of renal tumors, 7
RALP. *See* Robot-assisted laparoscopic radical prostatectomy; *See* Robotic-assisted laparoscopic pyeloplasty
RALSP. *See* Robot-assisted laparoscopic simple prostatectomy
RARC. *See* Robot-assisted radical cystectomy

RAVEIL. *See* Robotic-assisted video-endoscopic inguinal lymphadenectomy
Rectocele repair, 434–437
    posterior colporrhaphy for, 434–436, 436f–437f
    site-specific, 436–437
Rectourethral fistulas, 202, 204–209
    background on, 204–205
    complex, 207–209
    diagnosis of, 205
    etiology of, 202, 202t, 205
    overall condition and life expectance of patient with, 206
    simple, 206–207
    size and location of, 206
    sphincteric function with, 205
    spontaneous closure of, 205
    status of adjacent tissue, 205–206
    surgical management of, 205–209
        abdominoperineal approach in, 209
        gracilis interposition flap in, 208–209, 208f
        outcomes of, 209
        techniques in, 206–209
        transabdominal approach in, 209
        transanal approach in, 206, 206f
        transperineal approach in, 207–208, 208f
        York–Mason approach in, 206–207, 207f
    urethral stricture or bladder neck contracture with, 205
Rectovesical fistulas, 202. *See also* Intestinovesical fistulas
Rectus fascia bladder neck sling, 379–382. *See also* Bladder neck sling
Reduction cystoplasty, in prune belly (triad) syndrome, 765, 767, 767f
Remeex sling, 408
Renal artery embolization, for intracaval tumors, 26
Renal artery reconstruction, in renal transplantation, 104, 105f
Renal artery trauma, 101, 101f
Renal autotransplantation, 117–125
Renal blood vessels, anatomy of, 4–5, 5f
Renal cell carcinoma (RCC)
    alternative therapy for, 17
    cystic, 69
    diagnosis of, 16
    epidemiology of, 16
    in horseshoe kidney, 744
    intracaval extension of, 26–35
        diagnosis of, 26, 28f
        neoadjuvant targeted therapy for, 34–35
        outcomes and complications of, 35
        preoperative angioembolization of, 26
        surgical approach to, 26–34, 29f–34f
    radical nephrectomy for, 16–25

        - indications for, 16–17
        - laparoscopic, 17
        - outcomes and complications of, 24–25
        - results of, 25
        - surgical techniques in, 17–24, 17f–24f
    - staging of, 26
- Renal cysts. *See also* Autosomal dominant polycystic kidney disease
    - biopsy of, 73–74
        - laparoscopic, 74, 74f
        - percutaneous, 73–74
    - Bosniak classification of, 69, 70t, 71f
    - diagnosis of, 69
    - laparoscopic management of, 69–76
        - decortication in, 70–72, 72f
        - prevention of port-site metastases in, 72–73, 73t
        - retroperitoneal approach in, 71–72, 72f, 74
        - surgical technique in, 74
        - transperitoneal approach in, 72, 72f
    - malignancy risk of, 69
    - masses/indeterminant, 72–73
    - prevalence of, 69
    - simple, 69–70
- Renal fusion, 738–748. *See also* Ectopic kidney; *See also* Horseshoe kidney
    - diagnosis of, 741
    - embryology of, 738
    - surgical management of, 741–748
        - alternatives to, 742
        - indications for, 741–742
        - outcomes and complications of, 748
        - technique in, 742–748, 743f–747f
- Renal malrotation, 738
- Renal transplantation, 102–111
    - in adults and large children
        - catheter system for, 103, 103f
        - graft position and vascular anastomoses in, 104–106, 106f–107f
        - iliac fossa dissection in, 104, 105f
        - incision for, 103f, 104, 104f
        - instrumentation for, 103, 103t
        - patient positioning for, 103f
        - renal artery reconstruction in, 104, 105f
        - surgical technique for, 103–110
        - urinary tract reconstruction in, 106–108, 107f–108f
        - wound closure in, 108–109
    - anesthesiology team for, 103, 103t
    - autotransplantation, 117–125
        - alternatives to, 118
        - autograft implantation in, 122–123

    - autograft revascularization in, 123–124, 123f–124f
    - back-table preparation of renal autograft in, 122, 122f
    - closure in, 124
    - donor nephrectomy via midline intraperitoneal approach in, 121–122
    - flank donor nephrectomy in, 119–121, 121f
    - indications for, 118
    - instrumentation for, 118–119
    - operative approaches in, 119
    - outcomes and complications of, 124
    - technique of, 118–124
    - ureteroneocystostomy in, 123–124, 124f
  - complications of, 111, 111t
  - contraindications to, 102
  - donor nephrectomy for, laparoscopic, 36–43
    - alternatives to, 36
    - contraindications to, 36, 37t
    - donor evaluation for, 36
    - indications for, 36
    - left-sided, 37–41, 38f–41f
    - outcomes and complications of, 42–43, 42t
    - patient positioning for, 37, 38f
    - patient preparation for, 36
    - right-sided, 41
    - surgical techniques in, 36–41, 38f–41f
  - dual, 110, 110f
  - en bloc, 109–110, 109f
  - orthotopic, 109, 109f
  - outcomes of, 111
  - patient preparation for, 102–103
  - in small children, 110–111, 110f
  - ureteric complications after, 112–117
    - alternative therapy for, 113–114
    - categories of, 113t
    - diagnosis of, 112–113
    - ipsilateral native to allograft ureterostomy or ureteropyelostomy for, 116, 116f–117f
    - surgical indications in, 113
    - surgical management of, 113–116
    - surgical technique for, 114–116, 115f
    - ureterovesical reanastomosis (redo) procedure for, 115–116
- Renal trauma, 95–102. *See also specific types*
  - angioembolization in, 97, 97f
  - classification of, 95
  - complications of, 101
  - CT findings in, 96–97, 96f, 101
  - diagnosis of, 96
  - goal of care in, 96

  - hemodynamic instability in, 97
  - imaging of, 96, 96f
  - management of, 96–97
  - nephrectomy for, 98–101, 99f
  - postoperative care in, 101
  - reconstruction principles in, 99
  - renal exploration in
    - indications for, 97–98, 97t
    - midline incision for, 98, 98f
    - surgical technique in, 98–100, 98f–101f
  - renorrhaphy for, 100, 100f
  - renovascular injuries in, 101, 101f
  - urinary stenting/drainage in, 97

Renal tumors
  - active surveillance of, 7
  - cryoablation of, 7
  - diagnosis of, 43
  - in horseshoe kidney, surgery for, 744, 746f
  - imaging of, 7, 43
  - intracaval extension of, 26–35
  - laparoscopic nephrectomy for, 43–56
  - partial nephrectomy for, 7–15
    - indications for, 7
    - results of, 13
    - surgical techniques in, 8–12, 8f–12f
  - radical nephrectomy for, 16–25
    - indications for, 16–17
    - laparoscopic, 17
    - outcomes and complications of, 24–25
    - results of, 25
    - surgical techniques in, 17–24, 17f–24f
  - radiofrequency ablation of, 7

Renal vein trauma, 101, 101f

Renorrhaphy, 100, 100f

Reproductive organs. *See also specific organs*
  - female, preservation in radical cystectomy, 168–169, 169f, 235

Reservoir. *See* Continent catheterizable reservoir

Retrograde ejaculation, 508–509
  - evaluation of, 508, 508f
  - medical management of, 509
  - surgical management of, 509
  - treatment of, 508–509

Retrograde urethrogram
  - for anterior urethral trauma, 354, 354f
  - for posterior urethral trauma, 356–357, 357f

Retroperitoneal adrenalectomy, laparoscopic, 89, 92, 93f–94f

Retroperitoneal cystectomy, laparoscopic, 71–72, 72f, 74

Retroperitoneal fibrosis (RPF)
  alternative therapy for, 134
  diagnosis of, 134
  laparoscopic ureterolysis for, 134–136
Retroperitoneal lymph node dissection (RPLND), 537–547
  antegrade ejaculation disrupted by, 538, 539f
  boundaries of, 538, 538f, 544, 544f, 545f
  complications of, 546
  exposure of retroperitoneum in, 541–543, 541f–544f
  incision in, 541, 541f
  lymphadenectomy in, 544–545, 544f–545f
  nerve-sparing, 538–539, 539f, 540f
  perioperative preparation for, 540–541
  postoperative care in, 546
  preoperative preparation for, 539–540
  sperm cryopreservation before, 539
  surgical technique in, 541–545
Retroperitoneal nephrectomy
  laparoscopic, 47–48, 48f
  laparoscopic partial, 53–54
  pediatric laparoscopic, 875–876, 876f
  robotic partial, 54, 54f
Retroperitoneal pyeloplasty, pediatric laparoscopic, 868–869, 868f–869f
Retroperitoneal transureteroureterostomy, 750–751
Retropubic approaches, abdominal, for female incontinence, 388–392
Retropubic midurethral sling
  bottom-up, 384–385
  top-down, 382–384, 382f–384f
Retropubic prostatectomy, open radical, 261–262, 262f–263f, 269–276
  complications of, 275–276
  control of prostatic vascular pedicles in, 274, 274f
  dissection of seminal vesicles in, 274
  dividing urethra in, 272–273, 272f–273f
  identification and preparation of prostate in, 271
  incision in, 270
  incision of endopelvic fascia in, 271, 271f
  indications for, 269–270
  ligation of dorsal vein complex in, 271–272, 271f–272f
  neurovascular bundle preservation in, 273
  opening of Denonvilliers fascia in, 274
  operative technique in, 270–275
  patient positioning for, 270, 270f
  pelvic lymphadenectomy in, 270–271
  posterior mobilization in, 273, 273f
  postoperative care in, 275
  preoperative preparation for, 270
  reconstruction of bladder neck in, 274–275, 275f

  - transection of bladder neck in, 274, 274f
  - vesicourethral anastomosis in, 275, 275f
  - wound closure in, 275
- Retrourethral transobturator sling, 405–407
  - mechanism of action, 406
  - outcomes of, 406–407
  - surgical technique for, 405–406, 406f
- Retrovesical approach, to seminal vesicle, 452f, 453
- Retubularized colon segment, 729, 729f
- Rhabdomyosarcoma (RMS), 771–781
  - adolescent, 776–777
  - bladder, 772–773, 773f, 775, 776f, 779, 780f
  - diagnosis of, 772–773
  - dilemma of mature rhabdomyoblasts in, 780
  - epidemiology of, 771
  - outcomes of, 778–780
  - paratesticular, 773, 774f, 775–776, 777f, 779–780
  - pathologic features and molecular mechanisms of, 771–772
  - postoperative grouping for, 772, 773t
  - prostate, 772–773, 775, 776f, 779, 780f
  - risk stratification in, 777–778, 778t
  - staging of, 772, 772f, 773t
  - treatment of, 774–777
  - treatment algorithm for, 775f
  - uterine, 773, 776, 780
  - vaginal, 773, 774f, 776, 777f, 778f, 780
- Rhabdosphincter, 311, 312f, 314
- RMS. *See* Rhabdomyosarcoma
- Robot-assisted laparoscopic radical prostatectomy (RALP), 263, 284–291
  - anesthetic considerations in, 285
  - anterior approach in, 285, 288, 288f
  - benefits of, 284
  - bladder neck dissection in, 287–288, 287f–288f
  - complications of, 290–291
  - dissection of vasa and seminal vesicles in, 285–286, 288, 288f
  - division of dorsal vein complex and urethra in, 289, 289f–290f
  - exposure of prostatic apex in, 286–287, 287f
  - indications for, 284–285
  - ligation of dorsal vein complex in, 287, 287f
  - mobilization of bladder in, 286, 286f
  - nerve-sparing technique in, 289, 289f
  - patient positioning for, 285
  - pelvic lymph node dissection in, 286
  - portal placement and docking in, 285
  - posterior approach in, 285–286
  - posterior dissection between prostate and rectum in, 289
  - postoperative care in, 290

  - preoperative preparation for, 285
  - specimen retrieval and port closure in, 290
  - as standard of care, 284
  - surgical team for, 285
  - surgical technique in, 285–290
  - vascular control of lateral pedicles in, 289, 289f
  - vesicourethral anastomosis in, 290, 290f
- Robot-assisted laparoscopic simple prostatectomy (RALSP), 263–264
- Robot-assisted radical cystectomy (RARC), 230–242
  - alternatives to, 230–231
  - anatomic orientation in, 231
  - anterior dissection in, 233
  - complications of, 240–241
  - costs of, 241
  - Enhanced Recovery after Surgery protocol in, 231, 231t
  - functional outcomes of, 240
  - indications for, 230
  - lateral dissection of bladder and control of vascular pedicles in, 232–233, 233f
  - learning curve in, 241
  - lymphadenectomy in, 235, 235f, 236f, 239–240
  - in men, nerve-sparing modifications in, 233–234
  - mobilization and division of ureters in, 231
  - oncologic outcomes of, 238–240
  - patient positioning and port placement in, 231, 232f
  - postoperative care in, 238
  - preoperative preparation for, 231
  - quality of life after, 241
  - retrovesical dissection in, 231–232, 232f
  - specimen entrapment in, 233
  - surgical margins in, 239
  - transection of dorsal vein complex and membranous urethra in, 233
  - urinary diversion in, 236–238, 236f–238f, 240
  - in women
    - modifications for, 234–235
    - pelvic exenteration in, 234, 234f
- Robot-assisted ureteroscopy, flexible, 307–308, 307f–308f
- Robotic-assisted laparoscopic pyeloplasty (RALP), 85–86, 86f, 744–748, 747f, 866, 870–871, 870f–871f
- Robotic-assisted laparoscopic pyeloplasty (RALP), pediatric, 744–748, 747f, 866, 870–871, 870f–871f
- Robotic-assisted video-endoscopic inguinal lymphadenectomy (RAVEIL), 594
- Robotic bladder diverticulectomy (RBD), 242–243
  - concomitant procedure with, 243
  - extravesical, 242
  - postoperative care and follow-up in, 243
  - surgical technique in, 242–243
  - transvesical, 242–243

Robotic procedures. *See also specific procedures*
  bladder diverticulectomy, 242–243
  laparoscopic adrenalectomy, 89, 92–93, 94f
  laparoscopic nephrectomy, pediatric, 873, 877
  laparoscopic nephroureterectomy, 59, 63–64, 64f, 185, 188–189, 188f–189f
  laparoscopic sacral colpopexy, 433
  laparoscopic VUR repair, 789–794, 791f–794f
  megaureter reimplant, 761, 762f
  partial nephrectomy, 52–55
  prostate cancer, 307–308, 307f–309f
  radical cystectomy, 169–170, 230–244
  seminal vesicle surgery, 455
  transureteroureterostomy, 752
  vesicovaginal fistula repair, 200–201, 200t
Rosebud technique, in ileal conduit urinary diversion, 657–658, 658f

S
Sacher shunt, 608–609
Sacral colpopexy
  laparoscopic, 433, 433f
  open, 431–433, 432f–433f
  robot-assisted laparoscopic, 433
Sacral neuromodulation, 144–145, 411–419
  alternatives to, 412
  complications of, 228, 228t, 418
  history of, 411
  implantation of lead for, 414–418
    single-stage, 418
    stage II, 417–418
    stage I tined lead, 415–417, 416f–417f
  indications for, 412
  for interstitial cystitis/bladder pain syndrome, 224–225, 228–229, 228t
  mechanisms of action, 411
  outcomes of, 228–229, 418–419
  response testing in, 415, 415f, 415t
  sample/control settings for, 414, 414t
  S3 foreman localization for, 413–414, 414f
  size of InterStim for, 412, 413f
  surgical technique in, 412–417
  test stimulation for, 412–413
  timed lead for, 412, 413f
Sacrospinous ligament(s), 421, 422f
Sacrospinous ligament fixation, 430–431, 431f
Scaphoid megalourethra, 764, 764f
Sclerotherapy
  for hydrocele, 644
  for incontinence in women, 371

  - for lymphoceles, 127
- Scrotal agenesis, 905, 907–908
- Scrotal amputation, 558–560
- Scrotal approach, in simple orchiectomy, 522–524, 523f
- Scrotal ectopia, 905, 905f, 907, 907f
- Scrotal hematoma (contusion), 557, 557f–558f
- Scrotal hypoplasia, 905, 906–907
- Scrotal inclusion cysts, 905, 909, 909f
- Scrotal masses, epididymectomy for, 498–503
- Scrotal pain syndrome
  - counseling issues in, 498–499
  - epididymectomy for, 498–503
- Scrotal trauma, 554–566
  - avulsion, 554–555, 561–562, 561f
  - chemical (burns), 563
  - classification of, 554
  - diagnosis of, 554–557
  - foreign bodies in, 554–555
  - Fournier gangrene in, 556, 563–564
  - penetrating, 554–555, 558–560, 559f–560f
  - radiation-induced, 554, 556, 563, 564f–565f
  - simple orchiectomy for, 522
  - surgical management of, 557–566
    - alternatives to, 557–558
    - complications of, 564–566
    - indications for, 557
    - outcomes and complications of, 564–566
  - thermal (burns), 554, 555–556, 556f, 562–563, 563f
- Scrotum
  - anatomy of, 554, 554f, 572–575
  - blood supply of, 573–575, 575f
  - congenital anomalies of, 905–909
    - conservative management of, 905
    - diagnosis of, 905
    - genitourinary abnormalities with, 905
    - outcomes and complications of, 909
    - surgical indications in, 905
    - surgical techniques for, 906–909, 906f–909f
  - innervation of, 575
  - lymphatics of, 575
  - structure of, 572–573, 574f
- Selective serotonin reuptake inhibitors (SSRIs), for delayed ejaculation, 505
- Semen analysis
  - postepididymectomy, 501
  - postvasectomy, 467
  - postvasoepididymostomy, 487–488
  - postvasovasostomy, 481

Seminal fluid, 447
Seminal vesicle(s), 445–447
  anatomy of, 444f, 445–447, 446f, 449
  blood supply of, 446, 449
  development of, 445, 449
  dissection of
    in open radical retropubic prostatectomy, 274
    in robot-assisted laparoscopic radical prostatectomy, 285–286, 288, 288f
  function of, 447
  imaging of, 445, 445f, 449
  innervation of, 447, 449
  physical examination of, 445
  prostate relationship with, 245, 245f
Seminal vesicle chromotubation, 458
Seminal vesicle lesions
  alternative therapy for, 449
  diagnosis of, 449
  endoscopic treatment of, 455
  primary *vs.* secondary, 449
  surgical management of, 449–456
    indications for, 449–450
    laparoscopic techniques in, 454–455, 454f
    outcomes and complications of, 456, 456t
    paravesical approach in, 452–453
    preoperative preparation for, 450
    retrovesical approach in, 452f, 453
    robotic-assisted, 455
    techniques in, 450–456
    transcoccygeal approach in, 453–454, 453f
    transperineal approach in, 450–452, 451f
    transvesical approach in, 450, 451f
Seminiferous tubules, 441
Semirigid rod penile prostheses, 611, 611f, 619
Sentinel node biopsy, in penile cancer, 585–586, 585f–586f, 591
Sexual development, disorders of. *See* Disorders of sexual development
Sexual function, female, radical cystectomy and, 164
Shunts, for priapism, 607–610, 608f
Sigmoid colonic conduit, for palliative urinary diversion, 726
Sigmoidocystoplasty, 915–916, 917f
Sigmoid-rectal pouch, 716–724
Silicone polymers, urethral injection of, 375
Silver nitrate
  for hemorrhagic cystitis, 215
  for interstitial cystitis/bladder pain syndrome, 220
Simple renal cysts, 69–70
Simpson–Golabi–Behmel syndrome, 731
Sinus epididymis, 441

Sleeve technique, in circumcision, 897, 897f
Slings
  bladder neck, 379–388, 812–813, 812f
  fascial, 812–813, 812f
  male, 394, 395t, 402, 403–410
  for neurogenic bladder, 329
  pubovaginal, 320f, 321, 812–813, 812f
  urethral, female, 379–388
Small renal masses (SRMs)
  laparoscopic ablation of, 76–81
    complications of, 79–80
    contraindications to, 77
    indications for, 77
    mechanisms of action, 77–78
    perioperative preparation and considerations in, 78
    positioning, portal placement, and exposure in, 78
    postoperative care in, 79
    surgical technique in, 78–79, 78f–79f
  percutaneous biopsy of, 73–74
Snodgrass modification, for hypospadias, 830–831, 831f
Sober loop ureterostomy, for posterior urethral valve, 823–824, 823f
Sodium oxychlorosene, for interstitial cystitis/bladder pain syndrome, 220
Sodium pentosan polysulfate (SPPS)
  for hemorrhagic cystitis, 215–216
  for interstitial cystitis/bladder pain syndrome, 220
Sotos syndrome, 731
SPARC urethral sling, 382–384, 382f–384f
Spectra penile prosthesis, 611, 611f, 611t
Spermatic cord, 572, 574f
Spermatocele, 648–649
  definition of, 648
  diagnosis of, 648
  indications for treatment of, 648
  outcomes and complications of, 648–649
  surgical technique for, 648, 649f

Spermatocelectomy, 648, 649f
Spermatogenesis, 441
Sperm cryopreservation, 528, 539
Sperm maturation, 441, 443
Sperm retrieval, 516–517
    contraindications to, 516
    epididymal, 500, 520–521
        microsurgical, 500, 520–521, 520f
        outcomes of, 520–521
    intraoperative specimen evaluation in, 516–517
    quality and quantity of sperm retrieved in, 516
    in retrograde ejaculation, 508–509
    testicular, 517–520
        conventional, 518–519
        fine needle aspiration for, 517–518, 518f
        indications for, 517
        microscopic-assisted, 518–519, 519f
        open biopsy for, 517–518, 518f
        outcomes of, 519–520
        percutaneous biopsy for, 517–518, 518f
    timing of, 516
    vasoepididymostomy *vs.*, 482
    vasovasotomy *vs.*, 470
Sphincteric incontinence surgery, with augmentation cystoplasty, 911
Split prepuce in situ onlay hypospadias repair, 832, 832f
Squamous cell carcinoma
    penile, 576–596
    urethral, 360, 367
SRMs. *See* Small renal masses
Starr plication, for megaureter, 760, 760f
Stem cell therapy, for incontinence in women, 377
STING technique, for VUR, 798
Stones. *See* Calculus disease
Storage reflex, 143–144
Straddle injury, 353–356
Stress urinary incontinence (SUI)
    in men, postprostatectomy
        diagnosis of, 404
        male sling for, 403–410
        prevalence of, 403–404
        risk factors for, 404
        surgical indications in, 404
    in women
        abdominal retropubic approaches for, 388–392
        alternative therapies for, 380
        Burch urethropexy, 388–392
        diagnosis of, 379–380, 389

        - injection therapy for, 371–379
        - Marshall-Marchetti-Krantz (MMK) procedure for, 388–389
        - pathophysiology of, 379, 388
        - urethral slings for, 379–388
- Subcapsular orchiectomy, 525, 525f, 526f
- Subcoronal approach, to penile prosthesis implantation, 618
- Subcostal incision, in radical nephrectomy, 17f, 22–23
- Subepididymal orchiectomy, 525–526, 526f
- Substitution cystoplasty, for interstitial cystitis/bladder pain syndrome, 222–224, 224f
- Substitution urethroplasty, 341, 341f, 344–347
    - dorsal onlay graft for, 346, 346f–347f
    - penile skin flap for, 346–347, 347f
    - ventral onlay graft for, 344–346, 345f–346f
- Subureteric Teflon injection, for VUR, 798
- Supradiaphragmatic intracaval tumor, 33–34, 33f–34f
- Suprapubic catheter placement, for urethral trauma, 358–359, 359f
- Suprapubic orchiectomy, 524–525, 524f
- Suprapubic prostatectomy, 260–261, 261f–262f
- Supra-11th rib mini-flank surgical incision, 8–10, 8f–11f
- Supravesical diversion
    - for hemorrhagic cystitis, 216
    - for posterior urethral valve, 822–824, 822f–825f

T

- Tadalafil, for delayed ejaculation, 504
- Teflon
    - for female incontinence, 371
    - for vesicoureteral reflux, 784, 798
- Tegress, urethral injection of, 371
- TESA. *See* Testicular sperm aspiration
- Testicular amputation, 558–560
- Testicular appendage torsion, 548
- Testicular artery injury, varicocelectomy and, 495–496
- Testicular biopsy
    - for fertility purposes, 517–520
    - for intratubular germ cell neoplasia, 517
    - for sperm retrieval, 517–520
        - fine needle, 517–518, 518f
        - indications for, 517
        - open, 517–518, 518f
        - percutaneous, 517–518, 518f
- Testicular cancer (tumors)
    - alternative therapy for, 528
    - delays in diagnosis of, 528
    - diagnosis of, 527–528, 532, 532f, 533f
    - nonseminomatous, 527–528
    - organ-preserving surgery in, 532–537

        alternatives to, 532–533
        indications for, 532
        outcomes and complications of, 535–536
        surgical technique in, 533–534, 533f–536f
    radical inguinal orchiectomy for, 527–531
    retroperitoneal lymph node dissection in, 537–547
    scrotal ultrasound of, 528
    simple orchiectomy for, 521–527
    sperm cryopreservation in, 528, 539
    tumor markers in, 528
Testicular fracture, 557–558, 557f–558f
Testicular parenchyma, 514–515
Testicular prostheses, 524–525, 524f, 525f
Testicular sperm aspiration (TESA), 517–518, 518f
Testicular sperm extraction (TESE), 517–520
    conventional, 518–519
    microscopic-assisted, 518–519, 519f
    outcomes of, 519–520
Testicular torsion, 547–553
    age and, 547–548
    anatomy and, 572–573, 573f
    clinical presentation of, 548–549
    diagnosis of, 548–550
    differential diagnosis of, 549
    extravaginal, 547–549, 548f
    intravaginal, 547–548, 548f
    laboratory testing in, 549
    manual detorsion of, 550
    postnatal, 549, 549f
    prenatal, 549
    simple orchiectomy for, 521–522
    surgical management of, 550–553
        indications for, 550
        outcomes and complications of, 552–553
        technique of, 551–552, 551f
    ultrasound of, 549–550, 549f–550f
Testicular trauma, 554–566
    avulsion, 554–555, 561–562, 561f
    blunt, surgical technique for, 558, 558f
    chemical (burns), 563
    classification of, 554
    diagnosis of, 554–557
    foreign bodies in, 554–555
    Fournier gangrene in, 556, 563–564
    penetrating, 554–555, 558–560, 559f–560f
    radiation-induced, 554, 556, 563, 564f–565f
    simple orchiectomy for, 522

- surgical management of, 557–566
  - alternatives to, 557–558
  - indications for, 557
  - outcomes and complications of, 564–566
- thermal (burns), 554, 555–556, 556f, 562–563, 563f

Testis, 510–515. *See also specific disorders and procedures*
- blood supply of, 510–513, 513f, 514f, 573–575, 575f
- gross anatomy of, 510, 511f, 512f, 572–573, 574f
- histopathology of, 514–515, 515f
- innervation of, 514, 575
- lymphatic drainage of, 514, 575
- position of, 510
- spermatogenesis in, 441
- undescended (*See* Cryptorchidism)

Thermal ablation, of renal tumors, 7

Thermal injuries (burns), scrotal, 554, 555–556, 556f, 562–563, 563f

Thiersch-Duplay or primary tubularization, 830, 831f

Thiotepa, and hemorrhagic cystitis, 214

Thoracoabdominal incision, in radical nephrectomy, 17f, 20–22, 21f–22f

Thulium laser transurethral vaporesection of the prostate (ThuVARP), 260

Tibial nerve stimulation, 226–227, 227f, 412

Tiflis pouch, 706, 709f

Titan penile prosthesis, 611, 612f, 613

Top-down retropubic midurethral sling, 382–384, 382f–384f

Total penectomy
- complications of, 584–585, 585f
- indications for, 580
- postoperative care in, 584–585
- technique of, 583–584, 583f–584f

Total urogenital mobilization (TUM), 882–884, 882f–885f, 891–894, 892f–893f

Transabdominal bladder repair, 212–213, 213f

Transabdominal incision, in radical nephrectomy, 17f, 22–23, 23f

Transabdominal repair
- of rectourethral fistula, 209
- of vesicovaginal fistula, 197–199, 197f–199f, 200t

Transanal approach, to rectourethral fistula, 206, 206f

Transcoccygeal approach, to seminal vesicle, 453–454, 453f

Transitional cell carcinoma. *See* Urothelial (urothelial cell) carcinoma

Transitional epithelium, of bladder, 139, 140f

Transobturator midurethral sling
- inside-out, 386
- outside-in, 385–386, 385f–386f

Transobturator retrourethral sling, 405–407
- mechanism of action, 406
- outcomes of, 406–407
- surgical technique for, 405–406, 406f

Transperineal approach

  - to rectourethral fistula, 207–208, 208f
  - to seminal vesicle, 450–452, 451f
- Transperineal ultrasound, in delayed ejaculation, 503–504, 504f
- Transperitoneal nephrectomy
  - laparoscopic partial, 48–52, 48f–53f
  - laparoscopic radical or total, 44–47, 45f–47f
  - pediatric laparoscopic, 873–875, 874f–875f
  - robotic partial, 52–53, 53f
- Transperitoneal nephroureterectomy, laparoscopic radical, 61–66
- Transperitoneal pyeloplasty, pediatric laparoscopic, 867f, 869, 869f–870f
- Transperitoneal transureteroureterostomy, 750, 750f–751f
- Transrectal ultrasound (TRUS)
  - for brachytherapy guidance, 291, 293–297, 293f–295f
  - of ejaculatory duct obstruction, 456–457, 457f
- Transureteroureterostomy (TUU), 749–753
  - alternatives to, 749
  - indications for, 749
  - laparoscopic/robot-assisted, 752
  - outcomes and complications of, 752
  - retroperitoneal, 751–752
  - surgical technique in, 749–752
  - transperitoneal, 750, 750f–751f
- Transurethral incision of the prostate (TUIP), 253–255, 255t
- Transurethral injection, for incontinence in women, 372
- Transurethral microwave thermotherapy (TUMT), 252
- Transurethral needle ablation (TUNA), 252–253
- Transurethral nephroureterectomy, 190
- Transurethral resection
  - in bladder diverticulectomy, 173–174
  - in seminal vesicle surgery, 455
- Transurethral resection of the ejaculatory ducts (TURED), 458–459, 458f
- Transurethral resection of the prostate (TURP)
  - for benign prostatic obstruction
    - bipolar, 255–256
    - monopolar, 253–255, 255t
  - for urothelial carcinoma, 362
- Transvaginal repair
  - of enterocele, 427–431, 428f–431f
  - of vesicovaginal fistula, 195–197, 195f–197f, 200t
- Transvaginal/transrectal myofascial release, 218–219
- Transvaginal trigger point injections, 220–221, 221f
- Transverse colonic conduit, 661–666, 726
  - alternative to, 662
  - bowel segment for, 662, 662f
  - buttonhole technique for, 663, 663f
  - contraindications to, 661
  - Goodwin–Hohenfellner technique for, 663–664, 664f

- indications for, 661
- outcomes and complications of, 666
- patient preparation for, 661
- postoperative care of, 666
- preoperative examinations for, 661
- pyelotransverse pyelocutaneostomy for, 664–665, 665f
- surgical technique for, 662–666, 662f–665f
- Wallace technique for, 662–663, 663

Transverse retubularized colon segments, 729, 729f
Transvesical approach, to seminal vesicle, 450, 451f
Transvesical bladder diverticulectomy, 174, 175f
Transvesical bladder diverticulectomy, robotic, 242–243
Transvesical nephroureterectomy, 188–190, 188f, 190f
Transvesical repair, of vesicovaginal fistula, 199, 200f
Trazodone, for delayed ejaculation, 505
Triad syndrome (prune belly), 763–770
- abdominal wall reconstruction in, 765, 767–768, 768f
- anomalies associated with, 763–764
- classification of, 764
- diagnosis of, 764
- distal cutaneous ureterostomy in, 766
- epidemiology of, 763
- megalourethra in, 764f
- orchiopexy in, 765, 768–769
- reduction cystoplasty in, 765, 767, 767f
- surgical management of, 765–770
  - alternatives to, 765
  - indications for, 765
  - outcome and complications of, 769–770
  - techniques in, 766–769
- ureteral reconstruction in, 765, 766–767, 766f
- urethral reconstruction in, 765, 769, 769f–770f
- urinary tract reconstruction in, 765
- vesicostomy for, 766

Tricyclic antidepressants, for interstitial cystitis/bladder pain syndrome, 220
Trigone, 141, 141f
Trisomy 18, 731
True hermaphrodite, 886. *See also* Disorders of sexual development
T-shunt, 607
Tubularized incised plate urethroplasty, 830–831, 831f
TUIP. *See* Transurethral incision of the prostate
TUM. *See* Total urogenital mobilization
“Tumor stents,” for palliative urinary diversion, 727
TUMT. *See* Transurethral microwave thermotherapy
TUNA. *See* Transurethral needle ablation
Tunica albuginea
- of penis, 567–569, 568f

    - of testicle, 572
- Tunica vaginalis of scrotum, 572
- TURP. *See* Transurethral resection of the prostate
- TUU. *See* Transureteroureterostomy

U

- UCC. *See* Urothelial (urothelial cell) carcinoma
- Umbilical disorders. *See* Urachal anomalies
- Umbilical hernia, with bladder exstrophy, 844
- Undescended testis. *See* Cryptorchidism
- Upper tract urothelial carcinoma (UTUC)
    - alternative therapy for, 57–58
    - diagnosis of, 57, 185–186
    - epidemiology of, 56–57
    - kidney-sparing therapy for, 187
    - laparoscopic nephroureterectomy for, 56–68, 185–193
        - approach to distal ureter and bladder cuff dissection in, 64–66, 65f
        - complications of, 192
        - conventional, 61–62, 61f
        - extravesical bladder cuff technique in, 188–189, 189f
        - hand-assisted, 58, 62–63, 63f
        - indications for, 58–59, 186
        - lymphadenectomy in, 66
        - outcomes of, 66–67, 192
        - patient positioning for, 60–61, 60f
        - patient preparation for, 59–60
        - perioperative care and surveillance in, 66
        - pluck technique in, 191
        - robotic-assisted, 59, 63–64, 64f, 185, 188–189, 188f–189f
        - surgical techniques in, 59–66, 188–191, 188f–191f
        - transperitoneal radical, 61–66
        - transurethral, 190
        - transvesical, 188–190, 188f, 190f
        - ureteral unroofing technique in, 190–191, 191f
    - open nephroureterectomy for, 185–188, 192
        - extravesical approach with or without formal bladder cuff in, 187–188
        - indications for, 186
        - intravesical approach in, 187, 187f
        - lymphadenectomy in, 186, 186f
        - outcomes and complications of, 192
    - risk factors for, 57
    - staging of, 59, 59f
- Urachal adenocarcinoma, 148, 242, 807
- Urachal anomalies, 805–810
    - diagnosis of, 806–807
    - surgical management of, 807–809
        - indications for, 807–808

        outcomes and complications of, 808
        technique of, 808, 808f–810f
    types of, 806, 806f
Urachal cyst, 806–807, 807f. *See also* Urachal anomalies
Urachal diverticulum, 806–807. *See also* Urachal anomalies
Urachal remnant, 242
Urachal sinus, 806–807. *See also* Urachal anomalies
Urachus. *See also specific disorders and procedures*
    anatomy of, 242, 805–806
    closure or involution of, 806
    development of, 805, 805f
    excision of, 242
Ureter, enlarged. *See* Megaureter
Ureteral duplication, in VUR, 789, 790f
Ureteral intussusception (stripping), 191–192, 191f–192f
Ureteral leak/fistula
    alternative therapy for, 113
    after renal transplantation, 112–117
Ureteral obstruction
    alternative therapy for, 113
    ileal ureteral substitution for, 118
    laparoscopic pyeloplasty for, 81–87
    palliative urinary diversion for, 727–729, 728f–729f
    renal autotransplantation for, 117–125
    after renal transplantation, 112–117
Ureteral reconstruction
    in prune belly (triad) syndrome, 766–767, 766f
    transureteroureterostomy for, 749–752
Ureteral reflux
    alternative therapy for, 113
    after renal transplantation, 112–117
Ureteral reimplantation. *See also specific procedures*
    for VUR, 782, 783–791
Ureteral strictures
    diagnosis of, 134
    laparoscopic ureterolysis for, 134–136
Ureteral unroofing technique, 190–191, 191f
Ureteral vesical junction, 140–141
Ureteric complications, of renal transplantation, 112–117
    alternative therapy for, 113–114
    categories of, 113t
    diagnosis of, 112–113
    ipsilateral native to allograft ureterostomy or ureteropyelostomy for, 116, 116f–117f
    surgical management of, 113–116
        general considerations in, 114
        indications for, 113
        outcomes and complications of, 116–117

        patient preparation and exposure in, 114–115, 115f
        technique in, 114–116
    ureterovesical reanastomosis (redo) procedure for, 115–116
Ureterocalicostomy, 744, 745f–746f, 748
Ureterocele, 801–804
    diagnosis of, 801–802, 801f
        alternatives to, 802
        indications for, 802
        techniques in, 802–804, 802t
    endoscopic incision of, 802, 803f
    excision, with ureteral reimplantation, 802, 803f
    surgical management of, 802–805
        complete lower urinary tract reconstruction in, 802, 803f
        complete reconstruction in, 802t, 804
        outcomes of, 804
        upper pole ablation in, 802t, 803–804
        upper pole preservation in, 802–803, 802t
    upper pole nephrectomy and partial ureterectomy for, 803–804, 804f
    ureteroureterostomy/ureteropyelostomy for, 803
Ureterocutaneostomic stoma, construction of, 726
Ureterocystoplasty, augmentation, 919, 919f
Ureterolithotomy, open, 130
Ureterolysis, laparoscopic, 134–136
    indications for, 134
    outcomes and complications of, 136
    postoperative care in, 136
    surgical technique in, 134–136
Ureteroneocystostomy
    in renal autotransplantation, 123–124, 124f
    in renal transplantation, 106–108, 107f–108f
Ureteropelvic junction (UPJ) obstruction
    classification of, 753
    diagnosis of, 81, 753, 866–867
    endopyelotomy for, 82
    horseshoe kidney and, 741, 742–744
    laparoscopic pyeloplasty for, 81–87
        alternatives to, 82
        Anderson-Hynes dismembered method of, 83–85, 83f, 85f, 86f
        contraindications to, 81–82
        cystoscopy and retrograde ureterography for, 82
        drain placement and exit in, 85
        Endo Stitch for, 85, 86f
        entry and port placement in, 82, 83f
        exposure of operative field in, 82
        Fengerplasty method of, 83, 83f
        indications for, 81
        instrumentation for, 82

        intraoperative complications of, 86–87
        literature review of, 87
        mini-method of, 85
        natural orifice method of, 85
        patient positioning for, 82
        pediatric, 866–872
        postoperative care in, 86
        postoperative complications in, 87
        preoperative preparation for, 82
        pyelolithotomy in, 83, 85
        robotic-assisted, 85–86, 86f
        selecting type of repair in, 83, 83f–84f
        single-site method of, 85
        surgical alternatives in, 85–86
        surgical technique in, 82–85
        UPJ dissection in, 82–83
        ureteral stent placement for, 82
        Y-V plasty method of, 83, 84f, 85
    pediatric laparoscopic pyeloplasty for, 866–872
        alternatives to, 867
        indications for, 867
        outcomes and complications of, 871–872, 871t
        patient positioning for, 867, 867f
        retroperitoneoscopic approach in, 868–869, 868f–869f
        robot-assisted, 744–748, 747f, 866, 870–871, 870f–871f
        special considerations in, 870
        techniques in, 867–871
        transperitoneal approach in, 867f, 869, 869f–870f
    pediatric open pyeloplasty for, 742, 743f, 753–756
        alternatives to, 754
        indications for, 753–754
        open, 866
        outcomes and complications of, 756
        surgical technique for, 754–756, 754f–756f
    renal autotransplantation for, 118
    ureterocalicostomy for, 744, 745f–746f
Ureteropyelostomy
    for renal transplantation complications, 116, 116f–117f
    for ureterocele, 803
Ureteroscopy, flexible robot-assisted, 307–308, 307f–308f
Ureterosigmoidostomy, 716–724
    alternatives to, 717
    for bladder exstrophy, 847
    classical, 717–718, 717f–718f
    colorectal carcinoma after, 722–723
    continence rates with, 723
    contraindications to, 716

    indications for, 716
    Mainz pouch II technique in, 718–720, 719f–720f
    outcomes and complications of, 722–723
    preoperative preparation for, 717
    quality of life after, 723
    surgical technique in, 717–722
    surgical tricks in, 722
    upper urinary tract safety after, 723
Ureterostomy. *See also* Transureteroureterostomy; *See also* Ureterosigmoidostomy
    allograft, for renal transplantation complications, 116, 116f–117f
    bilateral, with single stoma, 726
    distal cutaneous, in prune belly (triad) syndrome, 766
    partial, for ureterocele, 803–804, 804f
    for posterior urethral valve
        end cutaneous, 824, 824f
        high cutaneous loop, 823, 823f, 824, 825f
        sober loop, 823–824, 823f
    transureteral cutaneous, 726
    transureteropyelocutaneous, 726
Ureteroureterostomy, for ureterocele, 803
Ureterovesical reanastomosis, 115–116
Ureterovesicostomy, in Mitrofanoff procedure, 928
Urethra, 311–314. *See also* Urethra, *See also* female; *See also* Urethra, *See also* male; *See also* *specific disorders and procedures*
Urethra, female, 311–312
    gross anatomy of, 311, 311f–313f, 569–570
    innervation of, 311
    lymphatics of, 312
    microscopic anatomy of, 311, 311f
    reconstruction of, 315–321
    structures contiguous to, 312, 313f
    vascular anatomy of, 311
Urethra, male, 246, 312–314
    gross anatomy of, 312–313, 314f, 447f
    in ileal orthotopic bladder substitution, 680–681, 681f
    innervation of, 313
    lymphatics of, 313–314
    microscopic anatomy of, 313
    structures contiguous to, 314
    vascular anatomy of, 313
Urethral cancer, 360–370
    histologic subtypes of, 360
    lymph node management in, 370
    male-to-female ratio of, 360
    in men, 361–366
        alternative treatments for, 362
        anatomy and, 361–362

        diagnosis of, 361
        epidemiology, risk factors, and presentation of, 361
        histopathology of, 361–362
        partial urethrectomy for, 364–365
        penile-preserving anterior urethrectomy with perineal urethrostomy for, 362–364, 363f–364f
        radical cystoprostatectomy with en bloc urethrectomy for, 365–366, 366f–367f
        recurrence, after radical cystectomy, 364
        staging of, 361, 361t
        surgical complications of, 366–367
        surgical treatment of distal tumors in, 362–365, 363f–364f
        surgical treatment of proximal tumors in, 365–366
    in women, 367–370
        alternative treatments for, 368
        anatomy and, 367
        diagnosis of, 367
        distal urethrectomy for, 368, 369f
        epidemiology, etiology, and risk factors of, 367
        histopathology of, 367
        radical urethrectomy with bladder preservation for, 368–370, 370f
        staging of, 367
        surgical treatment of distal tumors in, 368–370
        surgical treatment of proximal tumors in, 370
Urethral disruption. *See also* Urethral trauma
    complete, 354
    partial, 354
Urethral diverticulum, female
    coexisting conditions with, 322
    diagnosis of, 322–323, 323f
    formation of, 322, 323f
    urethral reconstruction for, 322–327
        alternatives to, 324
        indications for, 323
        outcomes and complications of, 326–327
        principles of, 324, 324t
        surgical technique in, 324–326, 324f–327f
Urethral fistula, female
    diagnosis of, 315–316
    diverticulectomy and, 326–327
    etiology of, 315, 315t
    urethral reconstruction for, 315–321
        advancement anterior vaginal flap for, 316, 317f
        alternatives to, 316
        bladder flap for, 318, 319f
        complications of, 321
        general principles of, 316, 316t
        indications for, 316

        - labia minora pedicle flap for, 318, 319f
        - outcomes of, 321, 322t
        - primary closure for, 316, 317f
        - pubovaginal sling for, 320f, 321
        - surgical technique in, 316–321
        - tube flap for, 318, 318f
        - vascular pedicle graft (Martius flap) for, 320–321, 321f
- Urethral fistula, male, urethroplasty and, 351, 351f
- Urethral injections, for female incontinence, 371–379
- Urethral lacunae, 313
- Urethral lengthening
    - Kropp procedure for, 814–816, 815f
    - Pippi Salle procedure for, 816–817, 816f
- Urethral reconstruction, female
    - for urethral diverticulum, 322–327
        - alternatives to, 324
        - indications for, 323
        - outcomes and complications of, 327
        - principles of, 324, 324t
        - surgical technique in, 324–326, 324f–327f
    - for urethral fistula, 315–321
        - advancement anterior vaginal flap for, 316, 317f
        - alternatives to, 316
        - bladder flap for, 318, 319f
        - general principles of, 316, 316t
        - indications for, 316
        - labia minora pedicle flap for, 318, 319f
        - outcomes and complications of, 321, 322t
        - primary closure for, 316, 317f
        - pubovaginal sling for, 320f, 321
        - surgical technique in, 316–321
        - tube flap for, 318, 318f
        - vascular pedicle graft (Martius flap) for, 320–321, 321f
- Urethral reconstruction, male, 336–352
    - anastomotic techniques for, 338–339, 341, 343–344, 344f
    - anatomic considerations in, 338–339, 339f
    - antibiotic prophylaxis in, 342
    - buccal mucosal harvest for, 342, 342f
    - complications of, 351, 351f
    - flaps for coverage in, 340
    - free grafts for, 339
    - general considerations in, 341–342
    - internal urethrotomy for, 338, 340–341, 340f, 342–343
    - outcomes and follow-up in, 351
    - patient positioning for, 341–342
    - perspectives on, 351
    - postoperative care in, 342, 343t

  preoperative and intraoperative decision making in, 340–341, 340f–341f
  principles of, 338–340
  skin flaps for, 339, 339f
  staged urethroplasty for, 347–351, 348f–351f
  substitution urethroplasty for, 341, 341f, 344–347, 345f–347f
  surgical techniques in, 342–351, 344f–351f
  urethral sonography in, 342
Urethral slings, for men. *See* Male sling
Urethral slings, for women, 379–388
  alternatives to, 380
  indications for, 380
  midurethral, 379–387
    bottom-up retropubic, 384–385
    inside-out transobturator, 386
    outside-in transobturator, 385–386, 385f–386f
    top-down retropubic, 382–384, 382f–384f
  outcomes and complications of, 386–387
  postoperative considerations with, 386
  preoperative considerations for, 380–381
  rectus fascia bladder neck, 379–382, 386–387
    abdominal incision for, 381
    adjusting tension of, 382, 382f
    cystoscopy of, 381
    fascial harvest for, 381, 381f
    suture passer advancement for, 381, 381f
    vaginal dissection for, 381
    wound closure for, 382, 382f
  surgical technique for, 380–386
Urethral-sparing cystectomy, in women, 169, 169f
Urethral strictures, male, 570, 570f
  anterior disease, 336–352
    algorithm for management of, 340f
    anastomotic techniques for, 338–339, 341, 343–344, 344f
    anatomic considerations in, 338–339, 339f
    buccal mucosal graft for, 342, 342f
    endoscopic studies of, 337–338
    epidemiology and pathophysiology of, 336
    evaluation of, 336–338
    flaps for coverage in, 340
    free grafts for, 339
    general surgical considerations in, 341–342
    internal urethrotomy for, 338, 340–341, 340f, 342–343
    outcomes and follow-up in, 351
    perspectives on, 351
    postoperative care in, 342, 343t
    preoperative and intraoperative decision making for, 340–341, 340f–341f
    radiographic studies of, 337, 337f–338f

        reconstructive principles for, 338–340
        skin flaps for, 339, 339f
        staged urethroplasty for, 347–351, 348f–351f
        substitution urethroplasty for, 341, 341f, 344–347, 345f–347f
        surgical complications in, 351, 351f
        surgical techniques for, 342–351, 344f–351f
    clinical presentation of, 336
    historical perspective on, 336
    individualized approach to, 336
    with rectourethral fistula, 205
Urethral trauma, 353–360
    anatomic considerations in, 353, 353f
    anterior, 353–356
        alternative therapy for, 354–355
        anatomy and, 353, 353f
        classification of, 354
        diagnosis of, 354, 354f
        outcomes and complications of, 356
        surgical indications in, 354
        surgical technique for, 355, 355f
    posterior, 356–359
        alternative therapy for, 358
        anatomy and, 353f, 356
        classification of, 357, 357t
        delayed urethroplasty for, 359
        diagnosis of, 356–357, 357f
        open suprapubic catheter placement for, 358–359, 359f
        outcomes and complications of, 359
        surgical indications in, 357–358
        surgical technique for, 358–359, 359f
Urethral valve
    anterior, 825–826
    posterior, 818–825
Urethrectomy
    in men
        anterior, with perineal urethrostomy, 362–364, 363f–364f
        en bloc, with radical prostatectomy, 365–366, 366f–367f
        in one-stage cystoprostatectomy, 155–158, 157f–158f
        partial, 364–365
    in women
        distal, 368, 369f
        radical, with bladder preservation, 368–370, 370f
        in radical cystectomy, 167, 167f
Urethropelvic ligaments, 420–421, 421f
Urethroplasty
    for anterior urethral trauma, 354–355, 355f
    for posterior urethral trauma, 359

    in prune belly (triad) syndrome, 769, 769f–770f
    staged, 347–351
        Asopa technique in, 348, 348f
        first stage of, 347–349, 348f
        second stage of, 349–351, 349f–351f
    substitution, 341, 341f, 344–347
        dorsal onlay graft for, 346, 346f–347f
        penile skin flap for, 346–347, 347f
        ventral onlay graft for, 344–346, 345f–346f
    Thiersch Duplay or primary tubularization, 830, 831f
    tubularized incised plate, 830–831, 831f
Urethrostomy, perineal
    with anterior urethrectomy, 362–364, 363f–364f
    with total penectomy, 583–584, 584f
Urethrotomy, internal, 338, 340–341, 340f, 342–343
Urethrovaginal fistula. *See* Urethral fistula, *See* female
Urethrovaginal sphincter, 311, 312f
Urgency urinary incontinence (UUI)
    alternative therapy for, 412
    diagnosis of, 411–412
    sacral neuromodulation for, 411
    surgical indications in, 412
Urinary bladder. *See* Bladder
Urinary diversion. *See also specific procedures*
    for anterior urethral trauma, 354–355
    for bladder cancer, 236–238, 237f–239f, 240
    for bladder exstrophy, 846, 847
    continent catheterizable reservoirs for
        colonic, 702–715
        ileal, 697–701
        Mitrofanoff principle/procedure for, 702, 923–930
    for hemorrhagic cystitis, 216
    in hypospadias surgery, 828
    ileal conduit, 656–660, 725–726, 725f
    for interstitial cystitis/bladder pain syndrome, 219, 224
    orthotopic bladder substitution for, 667–674
        colonic, 688–697
        ileal, 680–688
        ileal low-pressure, 674–679
    palliative, 724–730
        bilateral ureterostomy with single stoma for, 726
        double-J stents for, 727, 728, 728f
        eliminating function of contralateral kidney in, 727
        extra-anatomic pyelovesical prosthetic bypass for, 729
        ileal conduit for, 725–726, 725f
        indications for, 724–725
        metallic mesh stents for, 728–729

        - percutaneous nephrostomy for, 726–727
        - sigmoid colon conduit for, 726
        - surgical technique for, 725–727
        - transureteral cutaneous ureterostomy for, 726
        - transureteropyelocutaneous ureterostomy for, 726
        - transverse colon conduit for, 726
        - transverse retubularized colon segment for, 729, 729f
        - for ureteral obstruction, 727–729, 728f–729f
        - ureterocutaneostomic stoma for, 726
    - in prune belly (triad) syndrome, 765
    - transverse colonic conduit, 661–666, 726
    - ureterosigmoidostomy for, 716–724, 847
- Urinary retention
    - alternative therapy for, 412
    - diagnosis of, 411–412
    - sacral neuromodulation for, 411–419
    - surgical indications in, 412
- Urinary sphincter, artificial. *See* Artificial urinary sphincter
- Urinary tract infections, augmentation cystoplasty and, 183, 921
- Urinary tract reconstruction, in renal transplantation, 106–108, 107f–108f
- Urogenital mobilization
    - partial, 882f, 883–884
    - total, 882–884, 882f–885f, 891–894, 892f–893f
- Urogenital sinus anomalies, 877–885, 877f. *See also* Disorders of sexual development
    - clitoroplasty for, 879–880, 879f–880f, 883
    - decompression therapy for, 878–879, 882
    - diagnosis of, 878
    - labioplasty for, 881, 881f
    - partial urogenital mobilization for, 882f, 883–884
    - pure, 877, 878
    - surgical management of, 878–885, 891–894
        - outcomes of, 883–885, 894
        - techniques in, 879–883, 891–894
    - total urogenital mobilization for, 882–884, 882f–885f, 891–894, 892f–893f
    - vaginoplasty for, 880–881, 891, 891f–892f, 893–894, 893f
- Urolithiasis. *See* Calculus disease
- Urothelial (urothelial cell) carcinoma
    - bladder
        - diagnosis of, 148, 151
        - partial cystectomy for, 148–150
        - radical cystectomy in men for, 151–161, 233–234
        - radical cystectomy in women for, 161–171, 234–235
        - robotic radical cystectomy for, 230–244
    - prostate, 361t, 362
    - upper tract (*See* Upper tract urothelial carcinoma)
    - urethral, 360, 367
- Urothelium, 139, 140f

Uterine rhabdomyosarcoma, 773, 776, 780
Uterosacral ligament fixation, 429–430, 430f
Uterus, ligament support of, 421, 421f
UTUC. *See* Upper tract urothelial carcinoma

V

Vaginal canal
  anatomy of, 420
  pelvic organ prolapse and, 420–440
Vaginal hysterectomy, with vault suspension, 425–427, 425f–428f
Vaginal paravaginal repair, 434
Vaginal reconstruction, in radical cystectomy, 168, 168f
Vaginal rhabdomyosarcoma, 773, 774f, 776, 777f, 778f, 780
Vaginal trauma, with bladder trauma, 211
Vaginoplasty, 880–881
  cut-back, 880
  flap, 880, 883, 883f, 891, 891f–892f
  for high vaginal confluence, 881, 893–894, 893f
  for low vaginal confluence, 880, 891, 891f–892f
  pull-through, 881, 882
Varicocele, 490–497
  classification of, 490, 490t
  definition of, 490
  diagnosis of, 490
  hydrocele with, 494
  laparoscopic ligation of, 132–134
    alternatives to, 132
    indications for, 132
    outcomes and complications of, 133–134
    surgical technique in, 132, 132f–135f
  recurrence of, 496
  subclinical, 490
  surgical repair of, 490–497 (*See also* Varicocelectomy)
Varicocelectomy, 490–497
  alternatives to, 491
  anesthesia for, 491
  delivery of testis in, 494, 494f–495f
  dissection of cord in, 493–494, 493–494f
  hydrocele after, 495
  indications for, 490–491
  inguinal, 491–493, 491t
  microsurgical, 491–497
  outcomes and complications of, 495–496
  radiographic occlusion techniques in, 495
  subinguinal, 491–493, 491t, 492f–493f
  testicular artery injury in, 495–496
Vas deferens, 443–445

  - anatomy of, 444–445, 444f, 572–573, 574f
  - blood supply of, 445
  - congenital bilateral absence of, 443
  - development of, 444
  - function, 445
  - innervation of, 445
  - physical examination of, 443
- Vasectomy, 460–468
  - access in, 462, 462f–463f
  - alternatives to, 461
  - anesthesia for, 461–462, 461f–462f, 465
  - AUA guidelines on, 460
  - consultation on, 460
  - follow-up semen analysis in, 467
  - indications for, 460
  - minimally invasive, 462
  - no-scalpel technique in, 461, 463f, 465–466, 465f–466f
  - occlusion techniques in, 464–466, 464f, 466f
  - outcomes and complications of, 467–468
  - postoperative care in, 466
  - preferred technique in, 465–466, 465f–466f
  - reversal of
    - vasoepididymostomy for, 481–488
    - vasovasotomy for, 469–481
  - surgical technique in, 461–467
  - three-finger technique in, 462, 462f–463f
- Vasoepididymostomy, 481–488
  - alternatives to, 482
  - closure in, 486
  - completing anastomosis in, 485–486, 485f–486f
  - cost-benefit analyses of, 488
  - identification of appropriate epididymal tubule in, 482–483
  - indications for, 482
  - longitudinal intussusception, 483–485, 484f–485f, 487
  - maneuvers to gain extra length to bridge larger gap in, 487
  - outcomes and complications of, 488
  - postoperative care and follow-up in, 487–488
  - preparation of epididymal tubule and vas approximation in, 483, 483f
  - preparation of vas deferens in, 482
  - surgical caveats on, 487
  - surgical technique in, 482–488
  - technical challenge of, 481
- Vasovasostomy, 469–481
  - alternatives to, 470
  - anastomosis of vas deferens in, 476f, 477
  - anesthesia for, 471
  - closure in, 480, 480f

- complications of, 481
- exposure of vas deferens in, 471–472, 472f–473f
- incision for, 471, 471f
- indications for, 470
- multilayer microsurgical, microdot technique for, 477–480, 477f–480f
- operating room setup for, 470–471, 471f
- postoperative care and follow-up in, 481
- preoperative workup for, 469–470
- preparation of vas deferens in, 473f, 474
- prognostic factors in, 470
- special circumstances in, 480–481
- surgical technique in, 470–481
- vasal fluid evaluation in, 475–476, 475f–476f, 475t

Vena cava, renal tumor extension to. *See* Intracaval tumors
Venogenic (veno-occlusive) erectile dysfunction (VED), 620
- diagnosis of, 621–622, 621f
- vascular surgery for, 626–628
  - outcomes and complications of, 627–628
  - patient selection for, 626
  - technique in, 626–627, 627f–628f

Venovenous bypass, in intracaval tumor surgery, 34
Vesical neck. *See* Bladder neck
Vesicopelvic ligaments, 421
Vesicostomy
- in Mitrofanoff procedure, 927–928, 929f
- for posterior urethral valve, 820–822, 821f
- in prune belly (triad) syndrome, 766

Vesicoureteral reflux (VUR), 782–795
- American Academy of Pediatrics on, 782–783
- classification of, 782, 783f
- cross-trigonal (Cohen) repair of, 788–789, 789f
- diagnosis of, 782–783, 796
- ectopic kidney and, 748
- endoscopic treatment of, 784, 796–800
  - double hydrodistention implantation method of, 798–799, 798f–799f, 799t
  - indications for, 796–797
  - outcomes and complications of, 797, 797t, 799–800
  - patient positioning for, 798
  - STING (subureteric Teflon injection) in, 798
  - surgical technique in, 798–799
- flap-valve mechanism for, 782
- Glenn–Anderson repair of, 788, 788f
- minimally invasive repair of, 789–794, 791f–794f
- Paquin repair of, 789, 790f–791f
- Politano–Leadbetter repair of, 786–788, 787f
- primary, 782
- after renal transplantation, 112–113

  - secondary, 782
  - spontaneous resolution of, 782, 783–784, 796–797
  - surgical management of, 782, 783–791
    - alternatives to, 783–784, 797–798
    - with augmentation cystoplasty, 911
    - extravesical approach in, 784–785, 784f–785f
    - indications for, 783, 796–797
    - intra-extravesical approach in, 789, 790f–791f
    - intravesical approach in, 785–789, 786f–789f
    - outcomes and complications of, 794–795
    - postoperative care in, 794
    - techniques in, 784–794
  - ureteral duplication in, 789, 790f
  - voiding patterns in, 782
- Vesicovaginal fistula, 193–202
  - adhesive materials for, 195
  - definition of, 193
  - diagnosis of, 194
  - etiology of, 193, 193t
  - fulguration of, 194–195
  - historical perspective on, 193
  - locations of, 193–194
  - nonsurgical therapy for, 194–195
  - occlusive therapy for, 194–195
  - surgical repair of, 194–201
    - comparison of techniques, 200t
    - controversies over technique in, 201
    - excision of fistula edges in, 201
    - indications for, 194
    - laparoscopic and robot-assisted, 200–201, 200t
    - outcomes and complications of, 201
    - techniques in, 195–201
    - tissue interposition in, 201
    - transabdominal (intraperitoneal), 197–199, 197f–199f, 200t
    - transvaginal, 195–197, 195f–197f, 200t
    - transvesical (extraperitoneal), 199, 200f
- Virtue quadratic sling, 407–408, 407f–408f
- von Willebrand disease, 731
- VUR. *See* Vesicoureteral reflux

W

- WAGR syndrome, 731
- Waldeyer sheath, 141, 141f
- Wallace technique
  - for ileal conduit, 658–659, 659f
  - for transverse colonic conduit, 662–663, 663f
- Wallstent, for palliative urinary diversion, 728–729

Webbed penis, 895, 895f, 905, 908–909, 908f–909f
Wilms tumors, 731–738
    adjuvant therapy for, 736–737, 736t
    bilateral, 735–736
    diagnosis of, 731–732
    epidemiology of, 731
    in horseshoe kidney, 744
    recurrence of, 737
    staging of, 732, 732t
    surgical management of, 732–737
        indications for, 732
        outcomes of, 737
        preoperative considerations for, 732
        technique in, 732–736, 733f–735f
    syndromes associated with, 731
Winter shunt, 607, 608f

Y

Yachia longitudinal plication, 654, 654f
Yang–Monti technique, 706f, 925–927, 926f–928f
York–Mason approach, to rectourethral fistula, 206–207, 207f
Young–Dees–Leadbetter bladder neck repair, 813–814, 813f–814f, 852–853, 852f
Y-V plasty
    in laparoscopic pyeloplasty, 83, 84f, 85
    in pyeloplasty, 742, 743f
    in UPJ repair, in horseshoe kidney, 742, 743

Table of Contents

Titlepage
Copyright
Editors
Contributors
Remembrances
Preface
Section I Adrenal, Renal, Ureter, Pelvis
  1 Anatomy of the Adrenal Glands, Kidney, Ureter, and Pelvis
  2 Open Partial Nephrectomy
  3 Radical Nephrectomy
  4 Intracaval Tumors
  5 Donor Nephrectomy: Laparoscopic Techniques
  6 Laparoscopic/Robotic Nephrectomy and Partial Nephrectomy
  7 Minimally Invasive Nephroureterectomy
  8 Laparoscopic Renal Procedures: Renal Cystectomy, Biopsy, and Nephropexy
  9 Laparoscopic Ablation of Small Renal Masses
  10 Laparoscopic and Robotically Assisted Pyeloplasty in Adults
  11 Laparoscopic Adrenalectomy
  12 Renal Trauma
  13 Renal Transplantation
  14 Ureteric Complications Following Kidney Transplantation
  15 Renal Autotransplantation
  16 Miscellaneous Laparoscopic Urologic Procedures: Lymphoceles, Calculus, Varicocele, Ureterolysis
Section II Bladder
  17 Anatomy of the Bladder
  18 Simple and Partial Cystectomy
  19 Radical Cystectomy in Men
  20 Radical Cystectomy in Women
  21 Bladder Diverticulectomy
  22 Bladder Augmentation
  23 Management of the Distal Ureter for Nephroureterectomy
  24 Vesicovaginal Fistula
  25 Intestinourinary Fistulas
  26 Vesical Trauma and Hemorrhage
  27 Interstitial Cystitis/Bladder Pain Syndrome
  28 Minimally Invasive Bladder Procedures: Radical Cystectomy, Partial Cystectomy, Urachal Excision, Diverticulectomy
Section III Prostate
  29 Anatomy of the Prostate
  30 Surgery for Benign Prostatic Obstruction
  31 Open Radical Retropubic Prostatectomy
  32 Radical Perineal Prostatectomy
  33 Robotically Assisted Laparoscopic Radical Prostatectomy
  34 Brachytherapy for Localized Prostate Cancer

- 35 Imaging, Innovation, and Novel Therapies

Section IV Urethra

- 36 Anatomy of the Urethra
- 37 Female Urethral Reconstruction for Fistula and Female Urethral Diverticulum
- 38 Surgical Management of the Incompetent Bladder Outlet in the Patient with a Neurogenic Bladder
- 39 Anterior Urethral Stricture Disease
- 40 Surgery for Urethral Trauma Including Urethral Disruption
- 41 Carcinoma of the Urethra (Male and Female)
- 42 Injectable Therapies for Incontinence in Women
- 43 Urethral Slings
- 44 Abdominal Retropubic Approaches for Female Incontinence
- 45 The Artificial Urinary Sphincter
- 46 The Male Sling for Postprostatectomy Incontinence: Current Concepts and Controversies
- 47 Sacral Neuromodulation
- 48 Surgical Treatment of Pelvic Organ Prolapse

Section V Testis, Epididymis, Vas Deferens, And Seminal Vesicles

- 49 Anatomy of the Epididymis, Vas Deferens, and Seminal Vesicle
- 50 Seminal Vesicle and Ejaculatory Duct Surgery
- 51 Vasectomy
- 52 Vasovasostomy and Vasoepididymostomy
- 53 Microsurgical Varicocelectomy
- 54 Epididymectomy
- 55 Ejaculation Induction Procedures
- 56 Anatomy of the Testis
- 57 Sperm Retrieval Techniques
- 58 Simple Orchiectomy
- 59 Radical Inguinal Orchiectomy
- 60 Organ-Preserving Surgery in Testicular Tumors
- 61 Retroperitoneal Lymph Node Dissection
- 62 Torsion of the Testicle
- 63 Scrotal Trauma and Reconstruction

Section VI Penis And Scrotum

- 64 Penile and Scrotal Anatomy
- 65 Partial and Total Penectomy in the Management of Invasive Squamous Cell Carcinoma of the Penis
- 66 Inguinal Lymphadenectomy for Penile Carcinoma
- 67 Surgical Treatment of Peyronie’s Disease
- 68 Priapism
- 69 Penile Prosthesis Implantation
- 70 Penile Vascular Surgery
- 71 Penile Trauma
- 72 Penile Replantation
- 73 Hydrocele and Spermatocele
- 74 Congenital Curvature
- 75 Ileal Conduit Urinary Diversion

Section VII Urinary Diversion

76 Transverse Colonic Conduit
77 Managing the Patient with Orthotopic Bladder Substitution
78 Orthotopic Urinary Diversion Using an Ileal Low-Pressure Reservoir with an Afferent Tubular Segment
79 Ileal Neobladder
80 Colonic Orthotopic Bladder Substitution
81 Continent Catheterizable Reservoir Made from Ileum
82 Continent Catheterizable Reservoir Made from Colon
83 Ureterosigmoidostomy and Mainz Pouch II
84 Palliative Urinary Diversion
Section VIII Pediatrics
85 Wilms Tumor
86 Renal Fusion and Ectopia
87 Transureteroureterostomy
88 Pyeloplasty
89 Megaureter
90 Prune Belly (Triad) Syndrome
91 Childhood Rhabdomyosarcoma
92 Vesicoureteral Reflux
93 Endoscopic Treatment of Vesicoureteral Reflux
94 Ureteroceles
95 Urachal Anomalies and Related Umbilical Disorders
96 Vesical Neck Reconstruction
97 Surgery for Posterior Urethral Valves
98 Hypospadias
99 Complete Primary Repair for Exstrophy
100 Exstrophy and Epispadias—Modern Staged Approach
101 Pediatric Cryptorchidism, Hydroceles, and Hernias
102 Pediatric Laparoscopic and Robotic Pyeloplasty
103 Pediatric Laparoscopic Nephrectomy and Partial Nephrectomy
104 Urogenital Sinus and Cloacal Anomalies
105 Surgery to Correct Ambiguous Genitalia (46XX Disorder of Sexual Development)
106 Circumcision, Concealed Penis, and Scrotal Abnormalities
107 Augmentation Cystoplasty in Children
108 The Mitrofanoff and Malone Antegrade Continence Enema Procedures in Pediatric Urinary Tract Reconstruction
Index